Mars General Circulation Model Intercomparison

Participating Models:

GFDL John Wilson

Hokkaido Yoshiyuki Takahashi

LMD Francois Forget

Caltech/JPL (WRF) Michael Mischna

CCSR/NIES Takeshi Kuroda

York University (GM3) Youseff Moudden

MPI (MAOAM) Alex Medvedev

Second Mars Atmosphere Modeling and Observations Workshop, Granada, Spain, Feb. 27, 2006

Model	Horizontal Resolution	Vertical Levels	Dust Visible optical properties		
GFDL	60x36	22	w=0.92 g= 0.65		As for LMD
LMD	65x49	32	w=0.92 g= 0.55		3 IR channels
Hokkaido	120x60	48	Ockert-Bell		As for LMD
MAOAM	32x36	70/100 **		No CO_2 cycle	
CCSR	64x32	33	Ockert-Bell		9 visible 10 IR bands
WRF	64x36	25	w=0.92 g= 0.55		Dust IR: Haberle
York	40x20	102		No CO_2 cycle	
Ames	60x36 ??	24	Ockert-Bell		

** Log-pressure vertical coordinate

Requested Model Data

Diurnally-averaged U, V, and T fields on model levels
(optional diurnal composites: for thermal tides)

Diurnally-composited Ps, Ts and surface stress fields (12-24x/sol)

Model data centered on 3 Seasons:
L_s= 90, 180, 270

3 Dust Cases:

τ= 0.2, 1.0 and "mgs scenario"

zonally uniform dust; ideally with vertical distribution given by
Conrath parameter 0.01

Aerosol optical properties vary between models.

Aims

Assess qualitative aspects of the zonal mean circulation;

winds, temperature and mass transport streamfunction

Influence of horizontal and vertical resolution; particularly for surface stress.

Impact of different radiation parameterizations

Surface Pressure: 2 models lacked CO_2 cycle

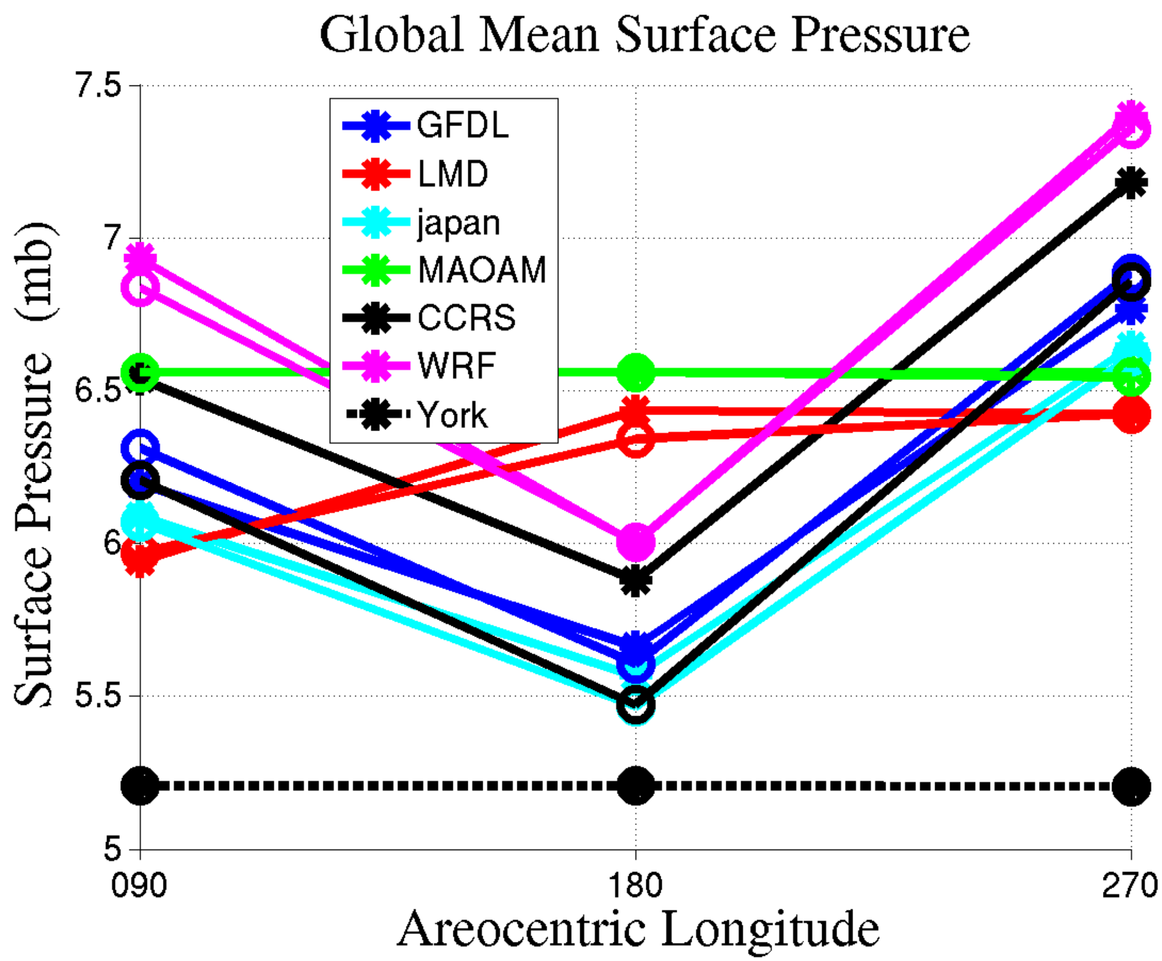
Surface Temperature: 2 models didn't enforce T_{CO2} for surface temperatures

1 model had very strong solar heating: evidently from solar absorption by dust. This had a major influence on all zonally-averaged fields.

1 model apparently had a deeper dust distribution than suggested

Surface stress magnitudes are quite variable in strength and location

Models all indicate a warm bias in polar temperatures during the L_s=180 season with respect to MGS TES observations.



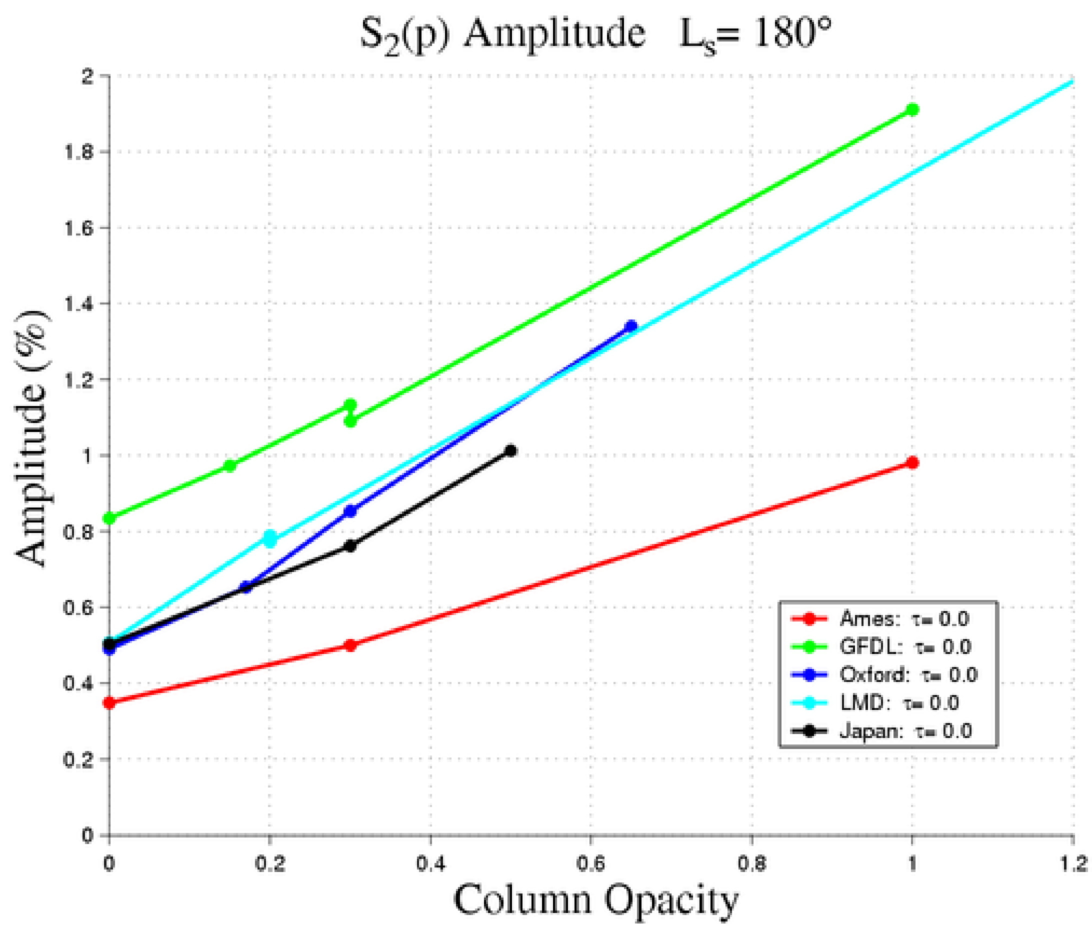
o τ=0.2

* τ=1.0

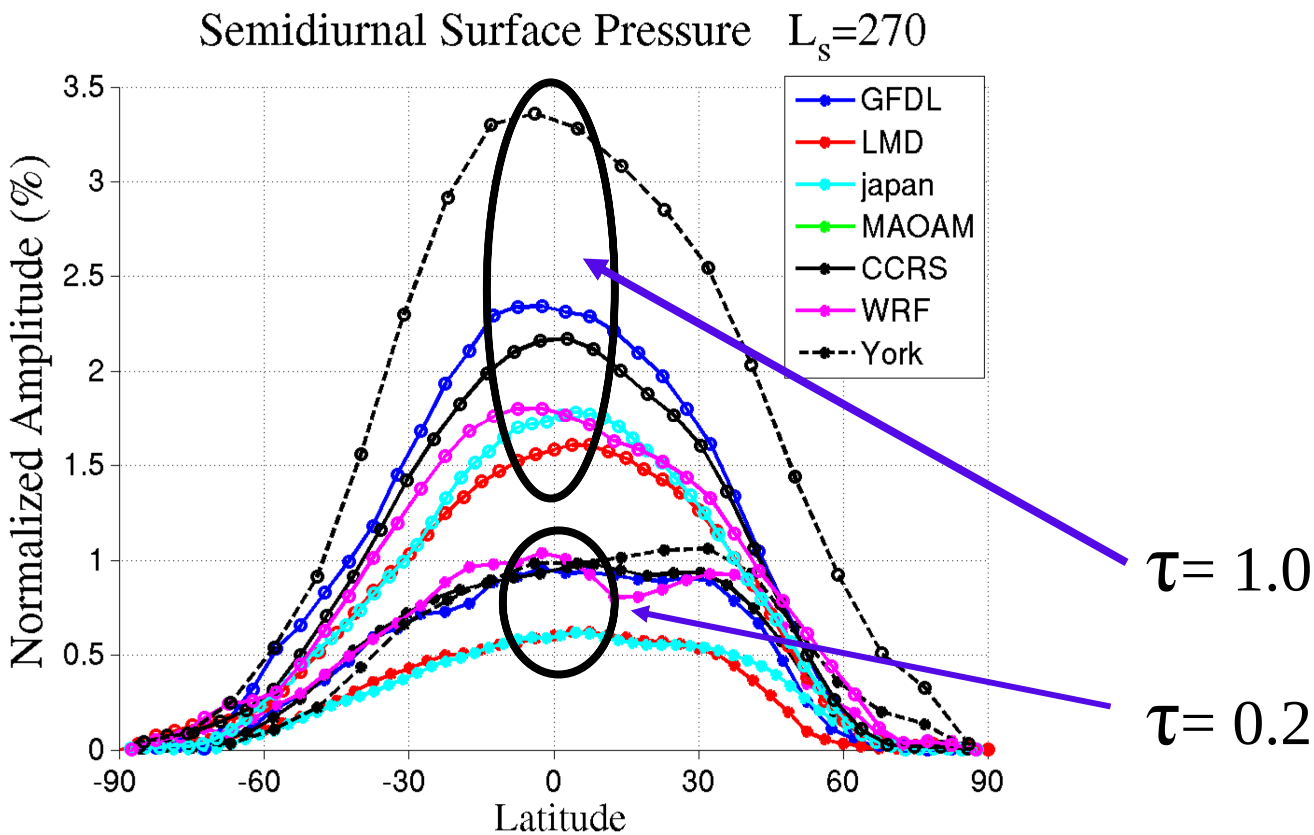
Semidiurnal Surface Pressure Amplitude

Tide amplitude vs dust column optical depth:

Tide is a measure of globally integrated thermal forcing due to surface heat flux and absorption by dust

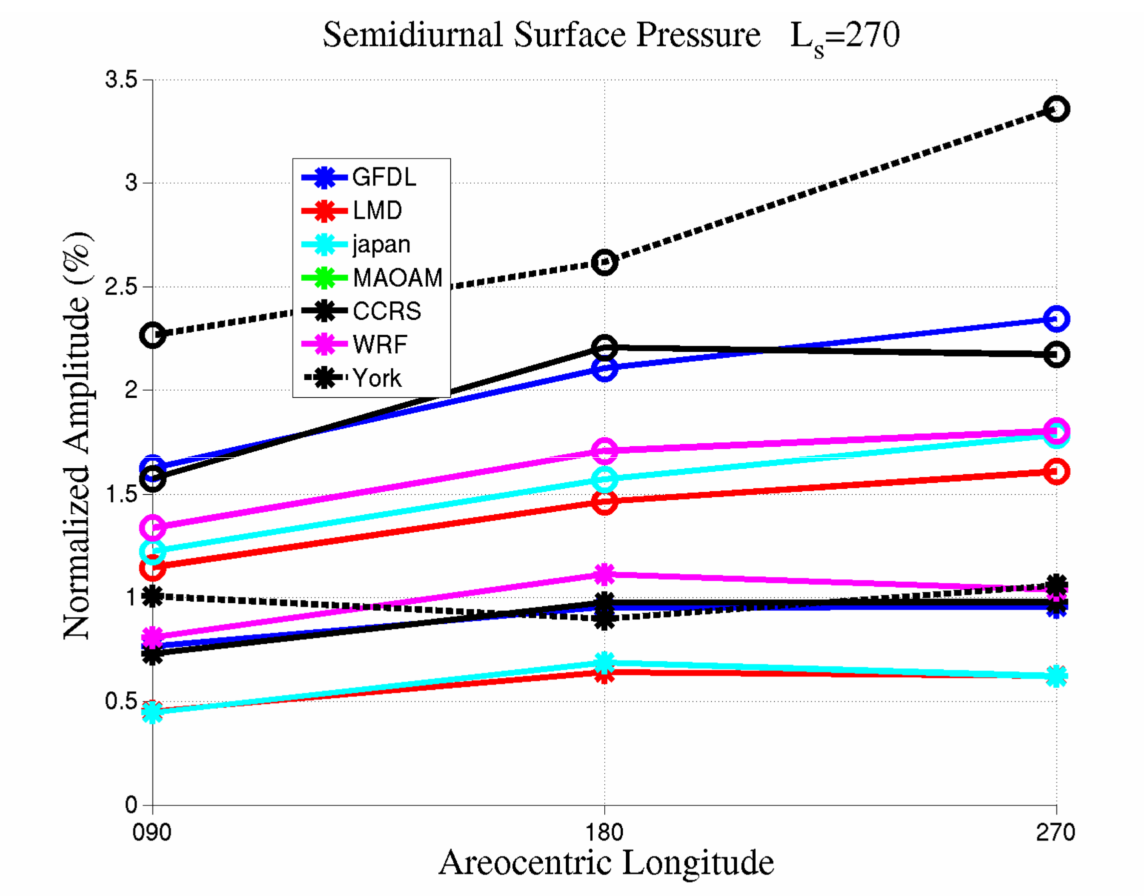


Results from model intercomparison; 2003 Granada meeting


Semidiurnal Surface Pressure L_s=270
Normalized Amplitude (%)
Latitude
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
τ= 1.0
τ= 0.2

Summary of Semidiurnal Tide Amplitude

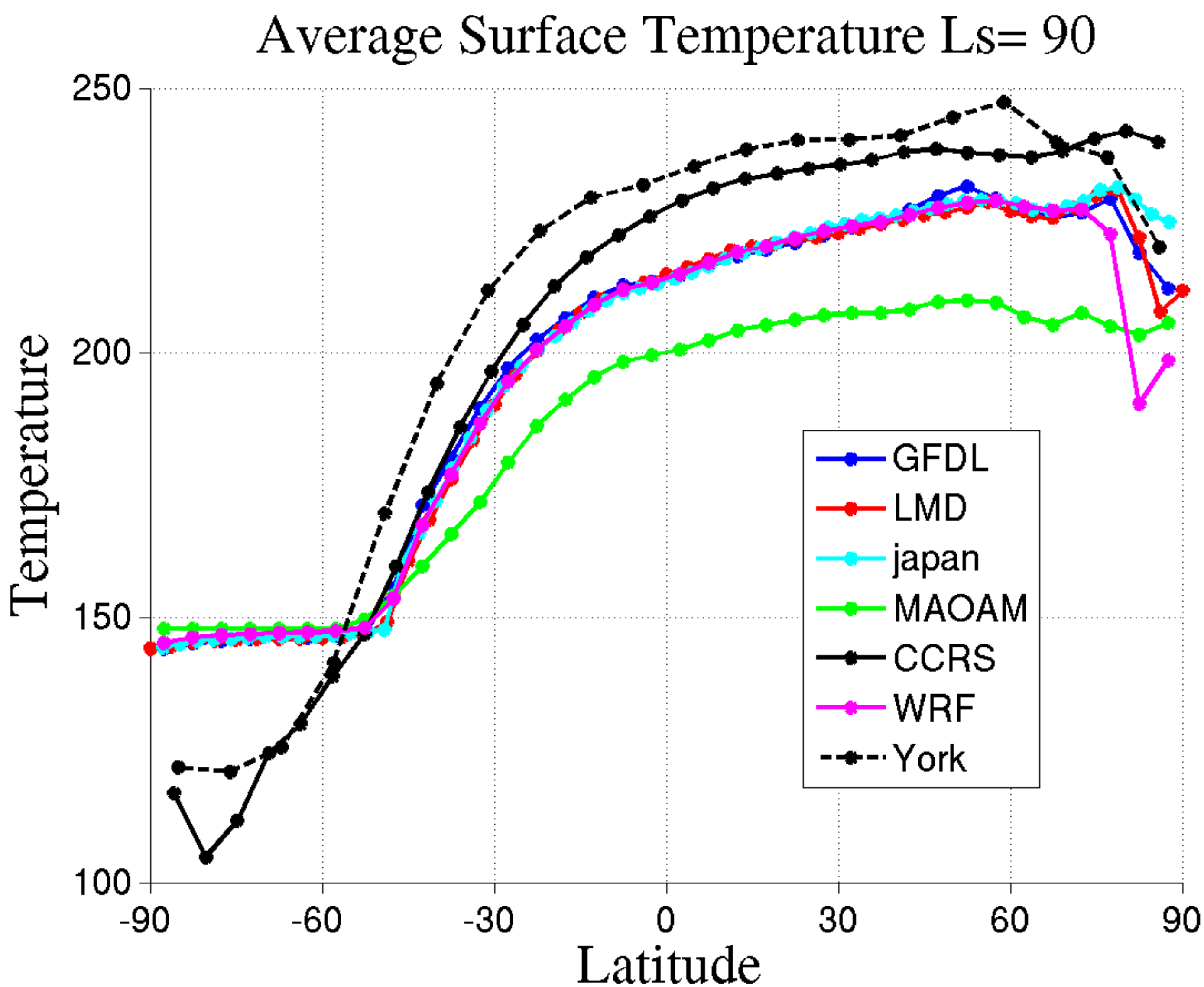
3 Seasons and 2 dust loadings



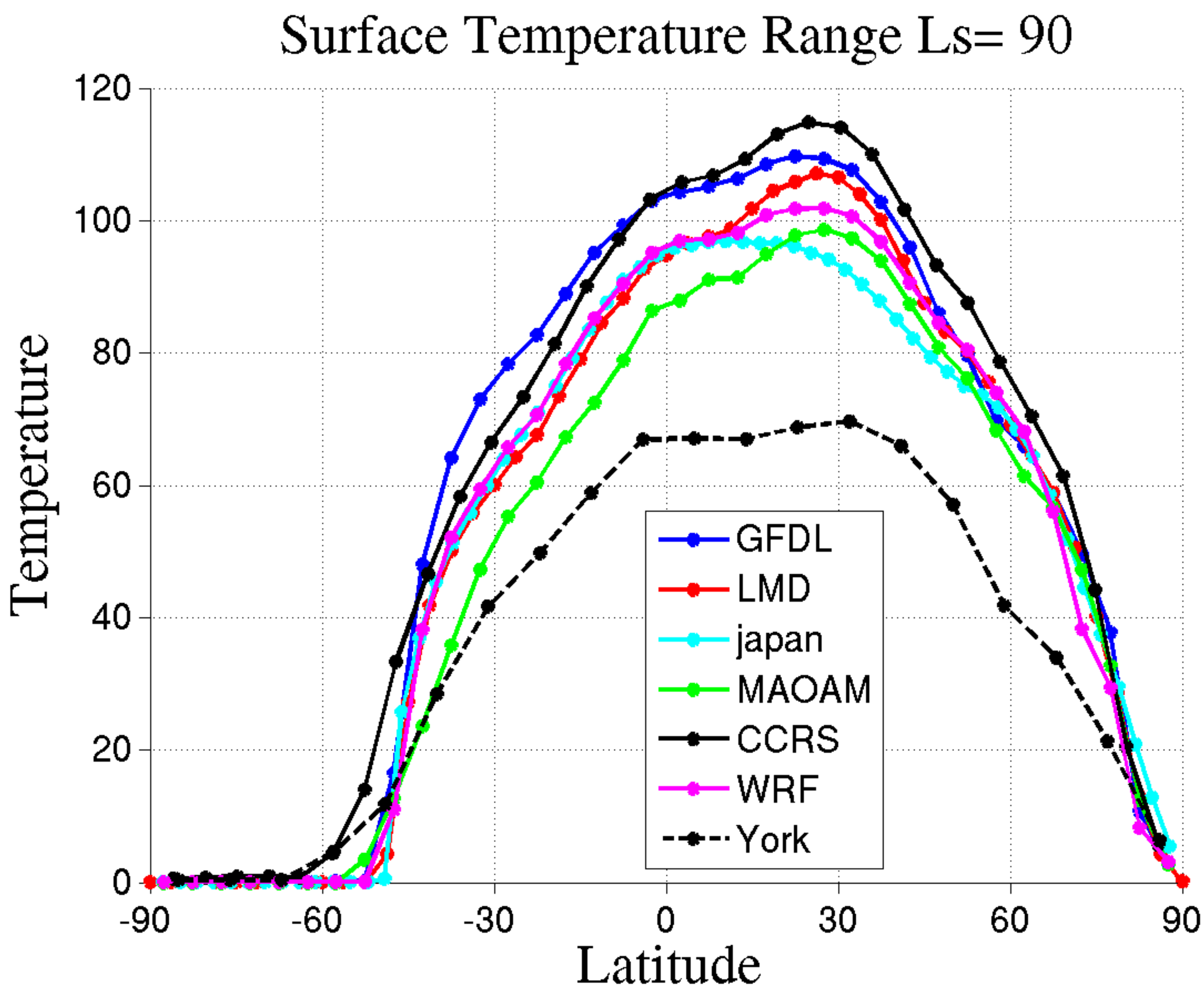
* τ =0.2

o τ= 1.0

L_s=90 L_s=180 L_s=270

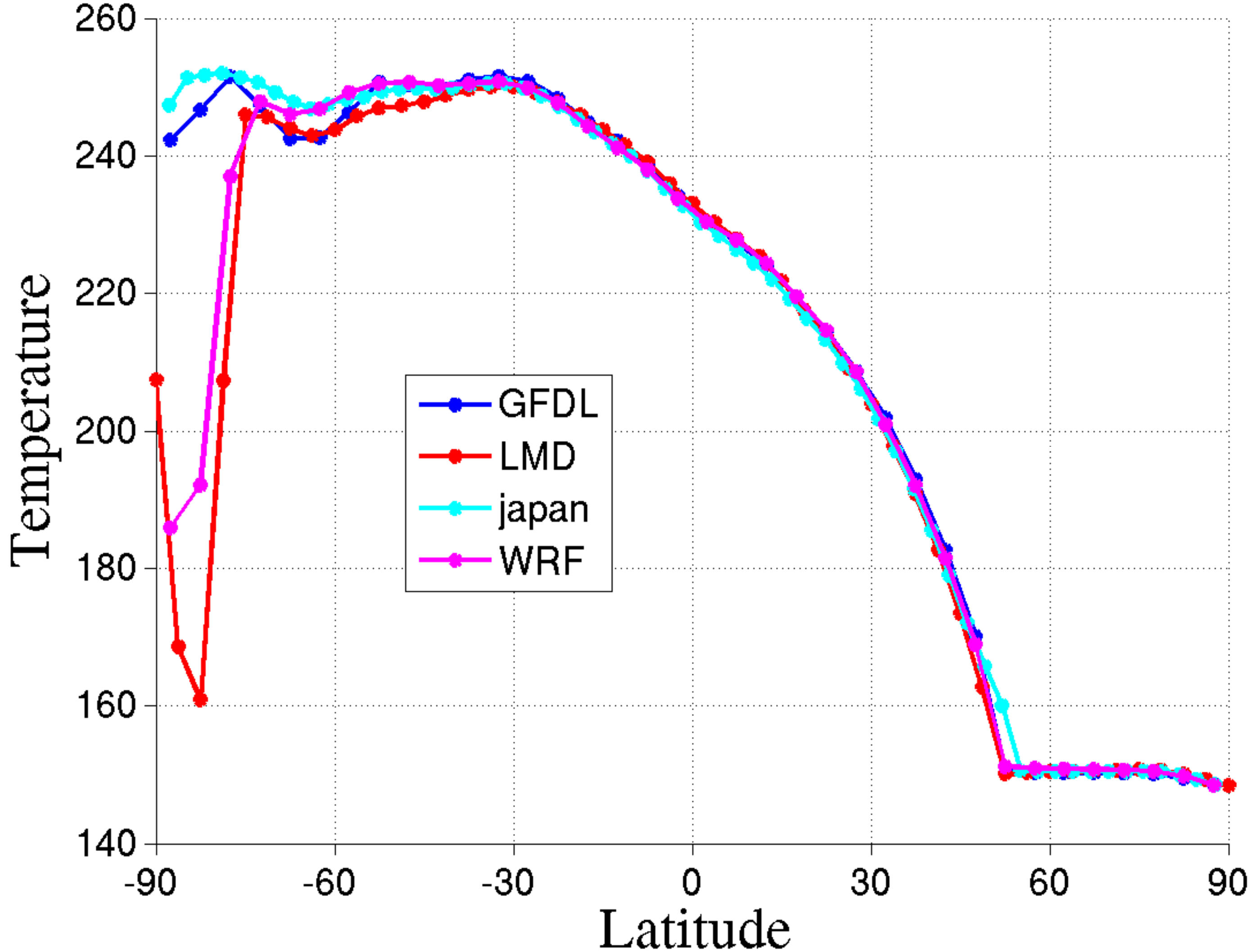


Average Surface Temperature Ls= 90
Temperature
Latitude
250
200
150
100
-90
-60
-30
0
30
60
90
GFDL
LMD
japan
MAOAM
CCRS
WRF
York



Surface Temperature Range Ls= 90
Temperature
Latitude
120
100
80
60
40
20
0
-90
-60
-30
0
30
60
90
GFDL
LMD
japan
MAOAM
CCRS
WRF
York

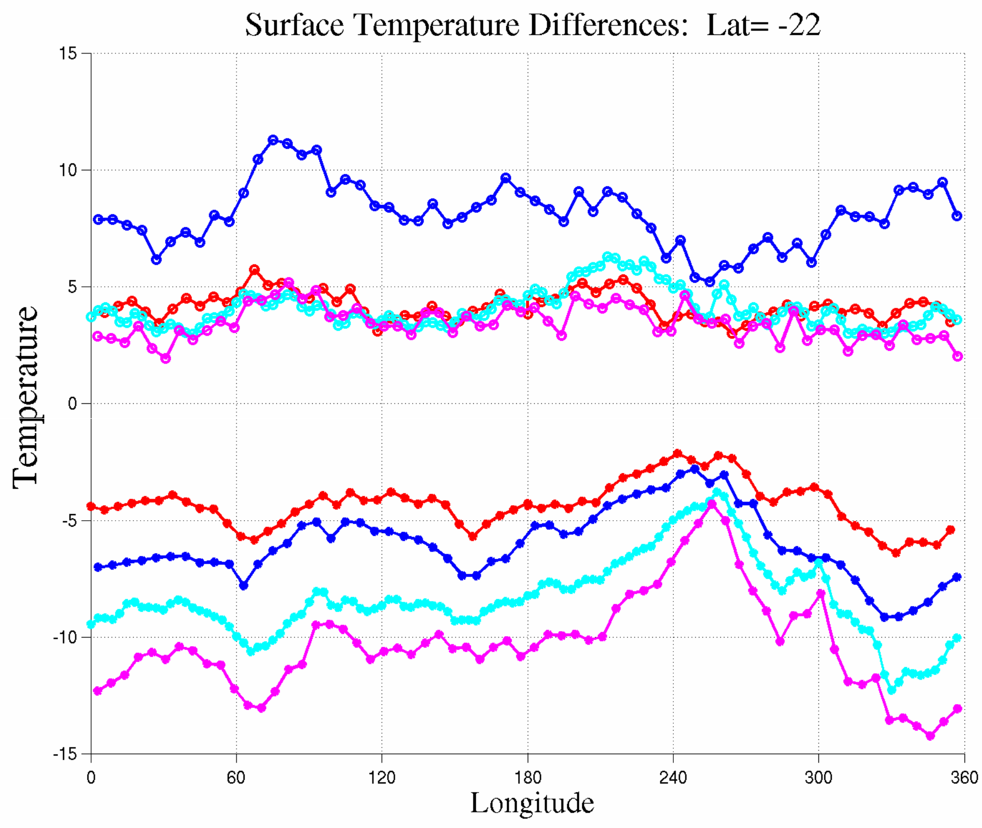
Avg Surface Temperature Ls= 270



Influence of Dust on Surface Temperature

$\Delta T_{sfc:}$ $T_{sfc}(\tau = 1) - T_{sfc}(\tau = 0.2)$

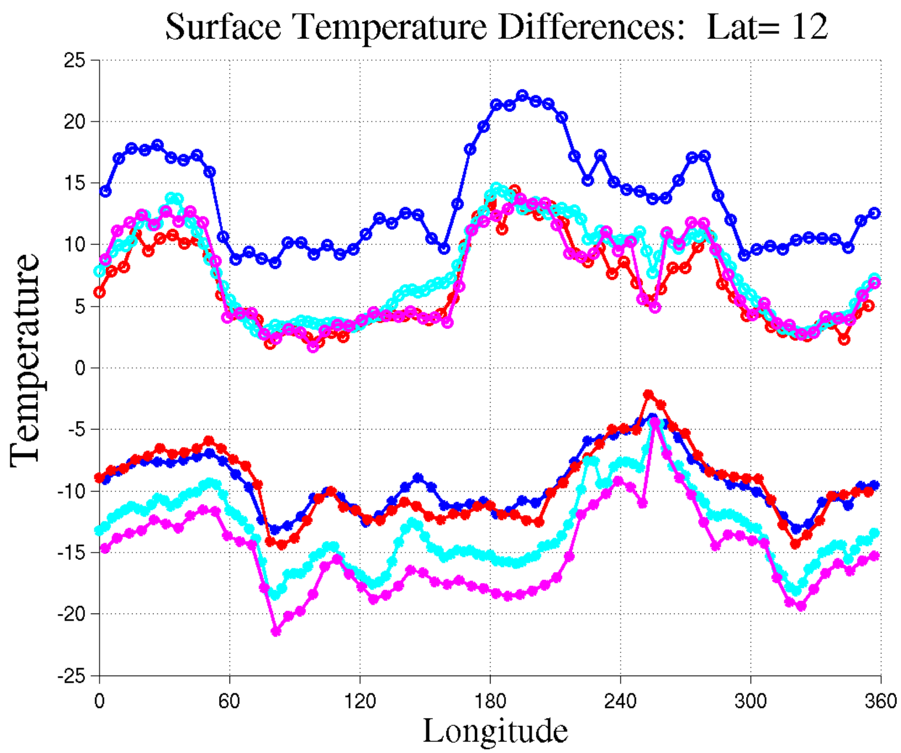
$L_s = 270$



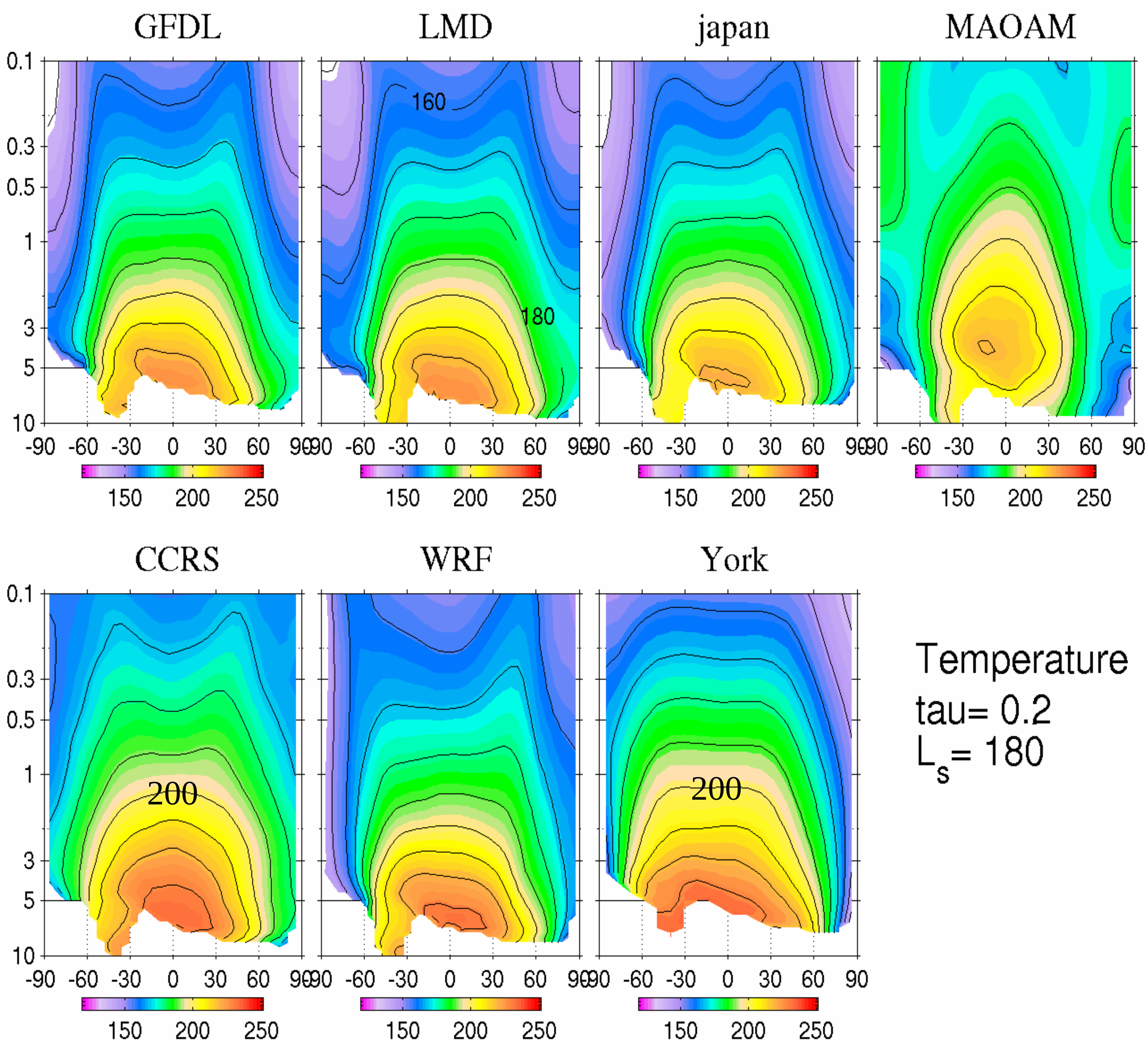
Dust increases minimum (am) temperature

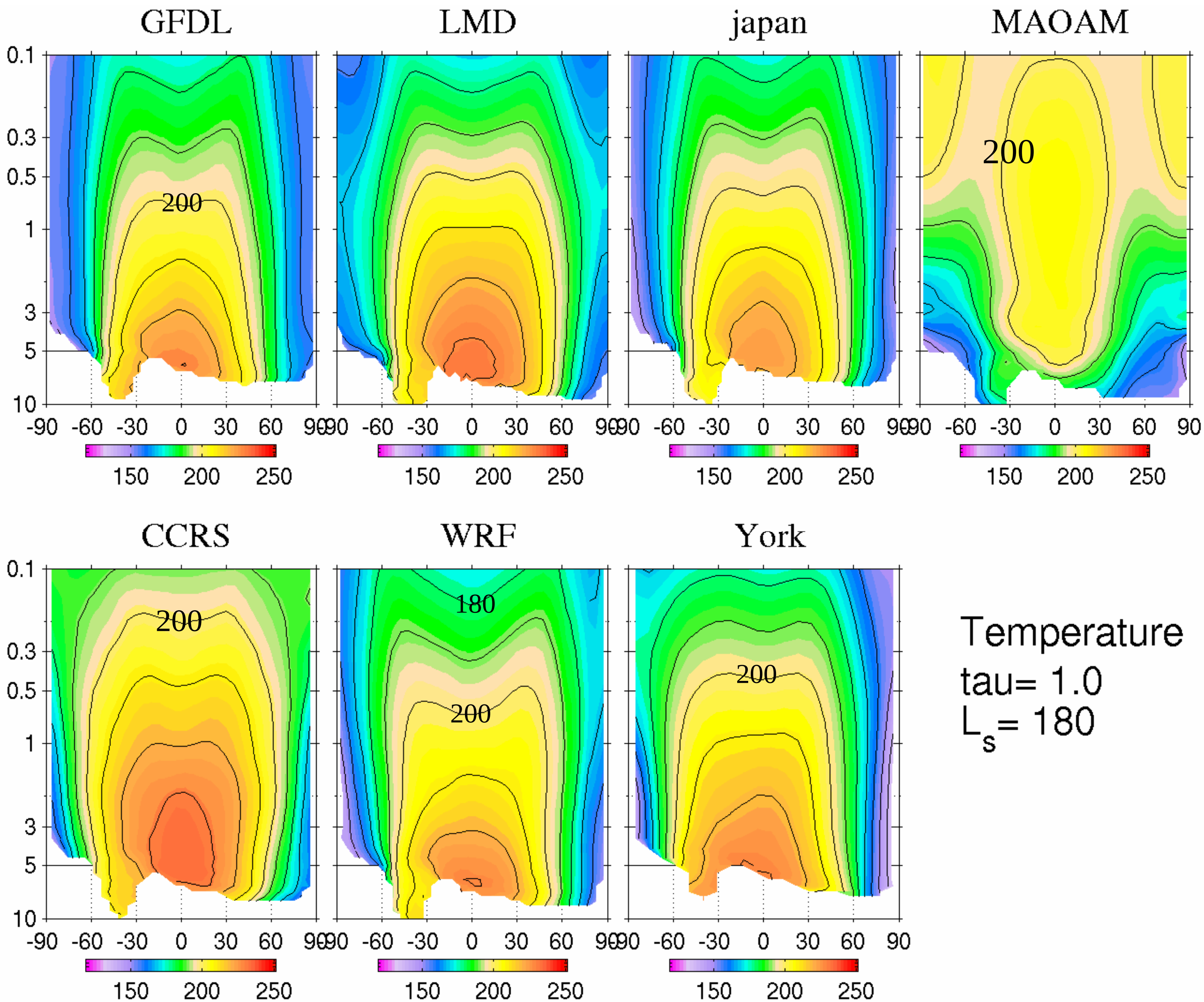
Dust decreases maximum (pm) temperature

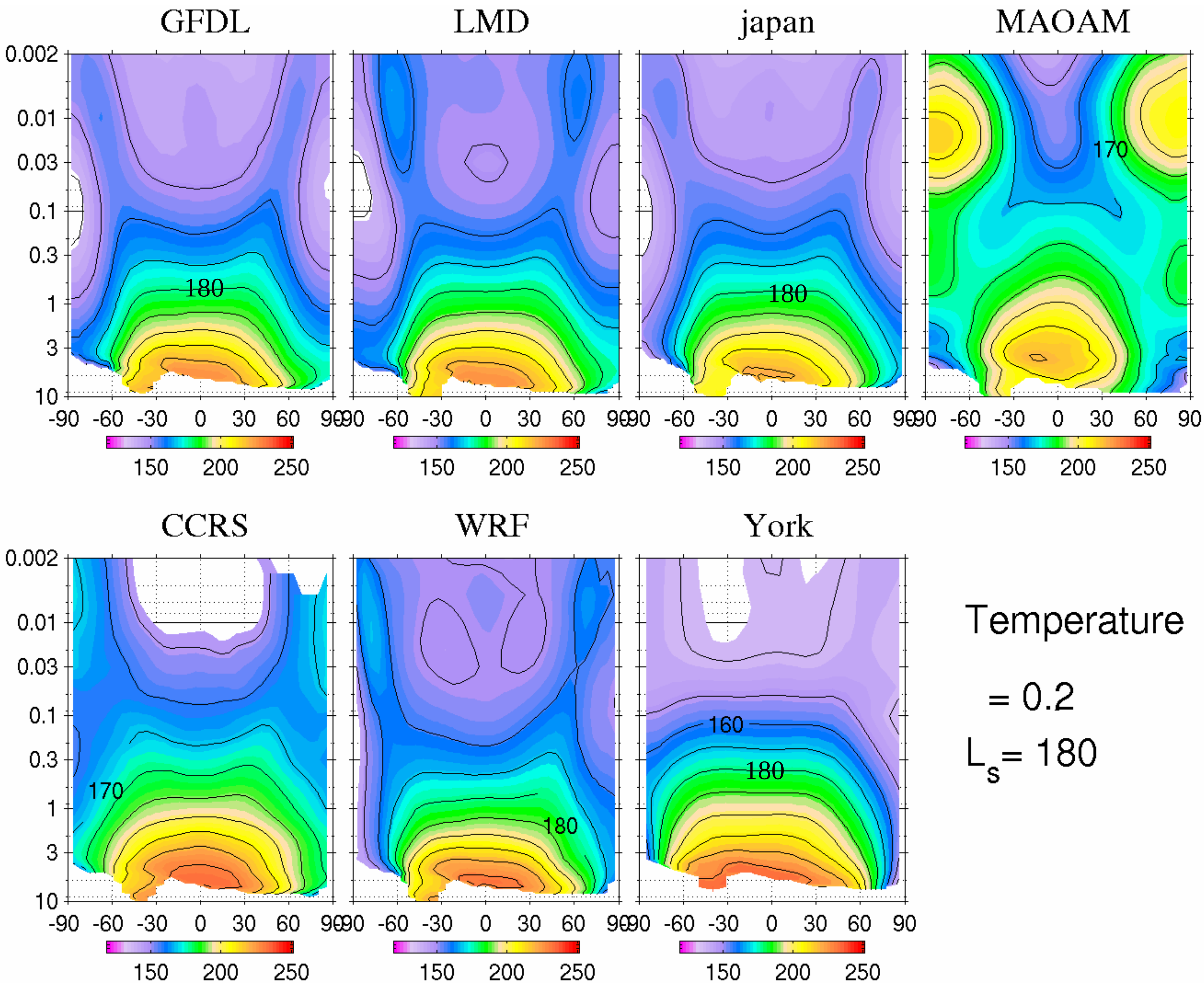
weak positive greenhouse effect: 3-5 K

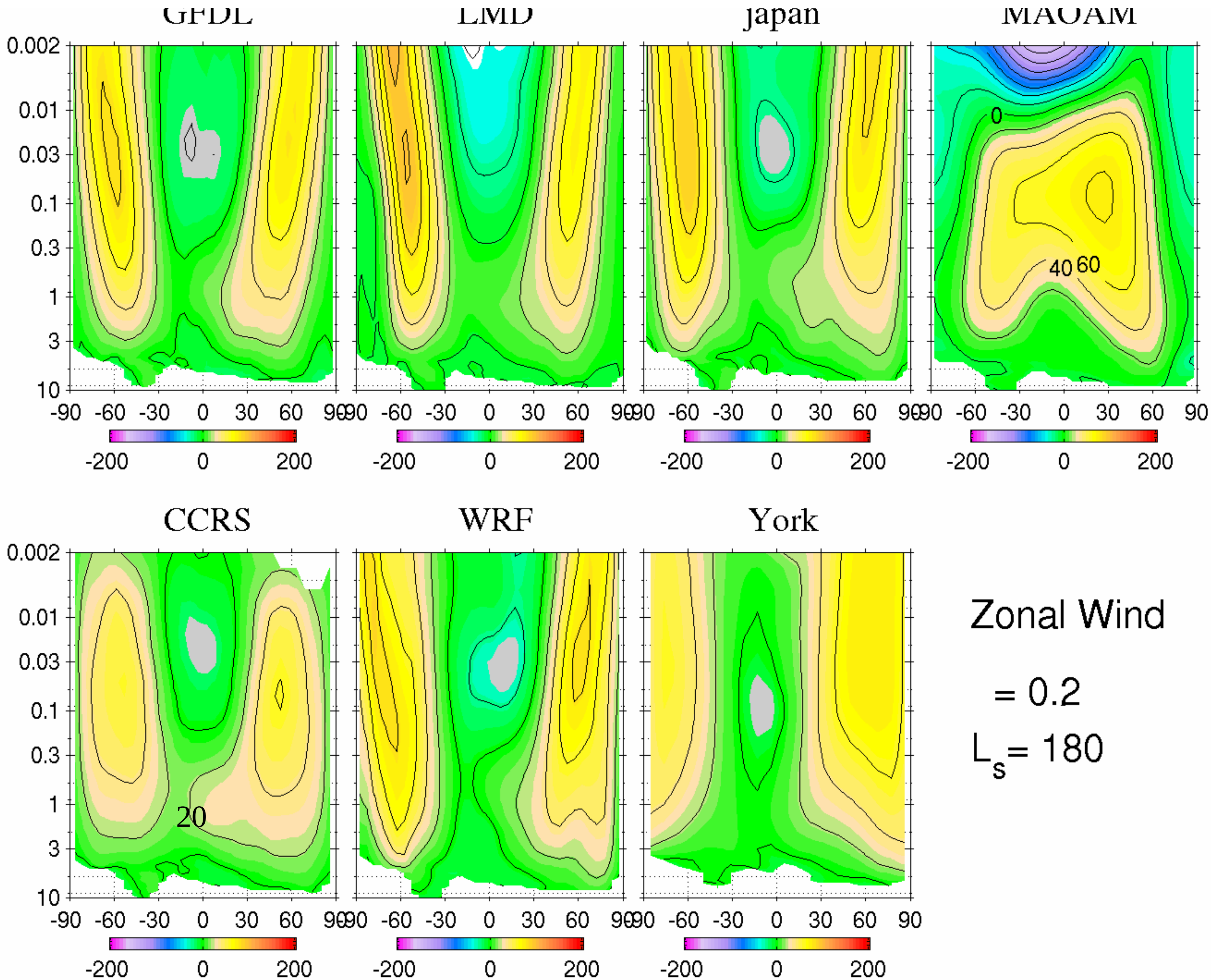


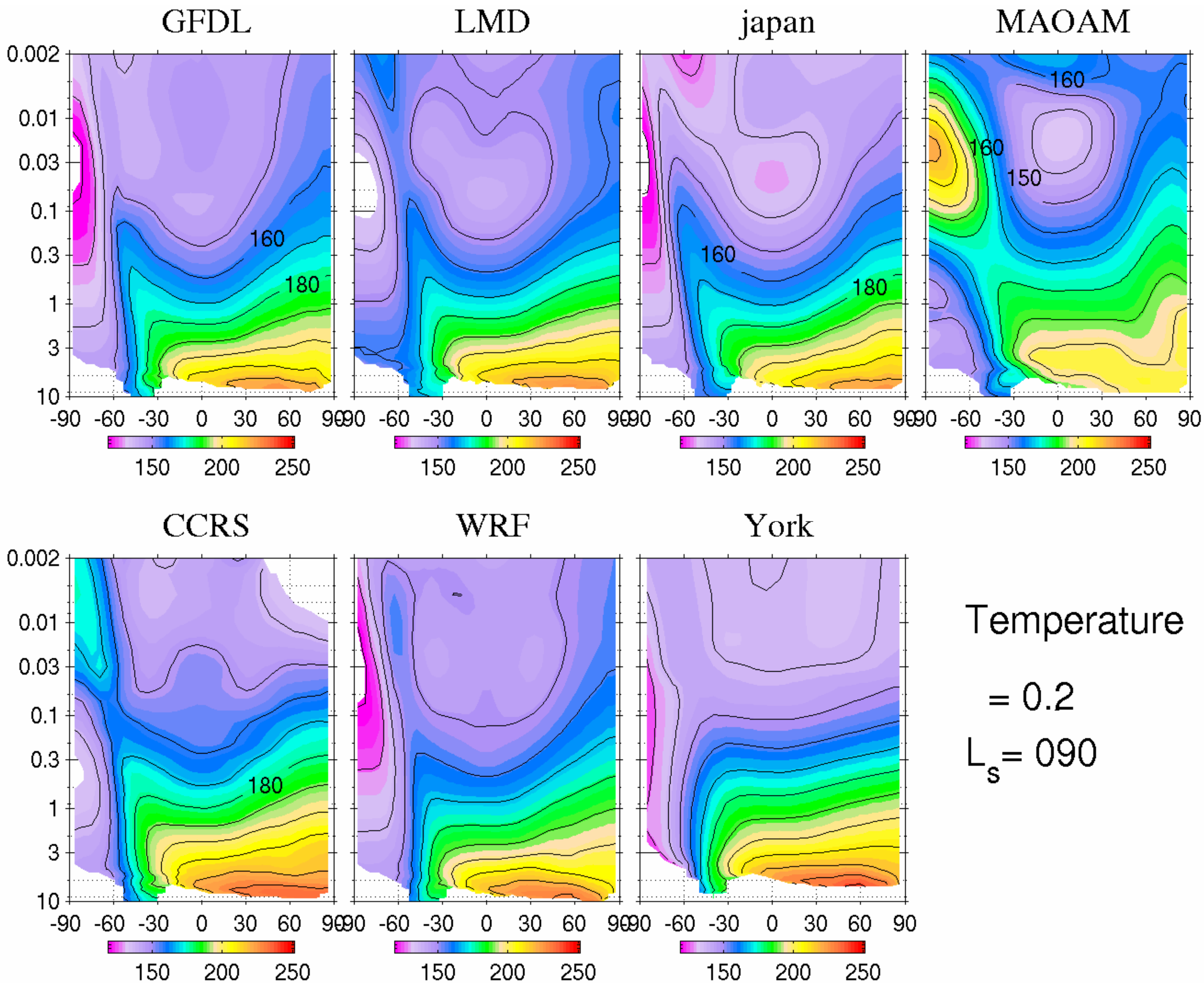
Dust influence is a function of surface thermal inertia: strongest when TI is smallest.


GFDL
LMD
japan
MAOAM
CCRS
WRF
York
160
180
200
200
0.1
0.3
0.5
1
3
5
10
-90 -60 -30 0 30 60 90
150 200 250
Temperature
tau= 0.2
L_s= 180

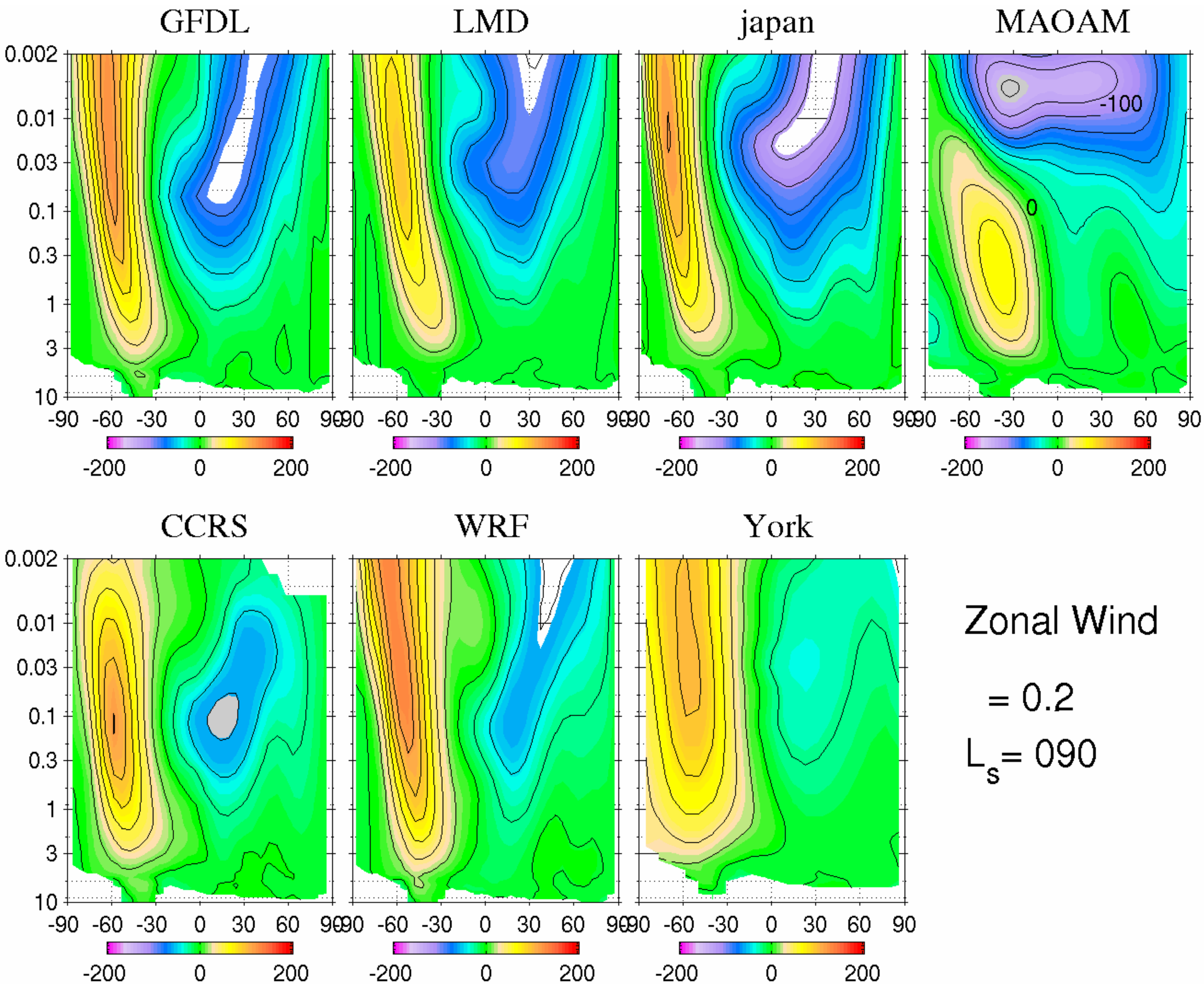

GFDL
LMD
japan
MAOAM
CCRS
WRF
York
200
180
0.1
0.3
0.5
1
3
5
10
-90 -60 -30 0 30 60 90
150 200 250
Temperature
tau= 1.0
L_s= 180

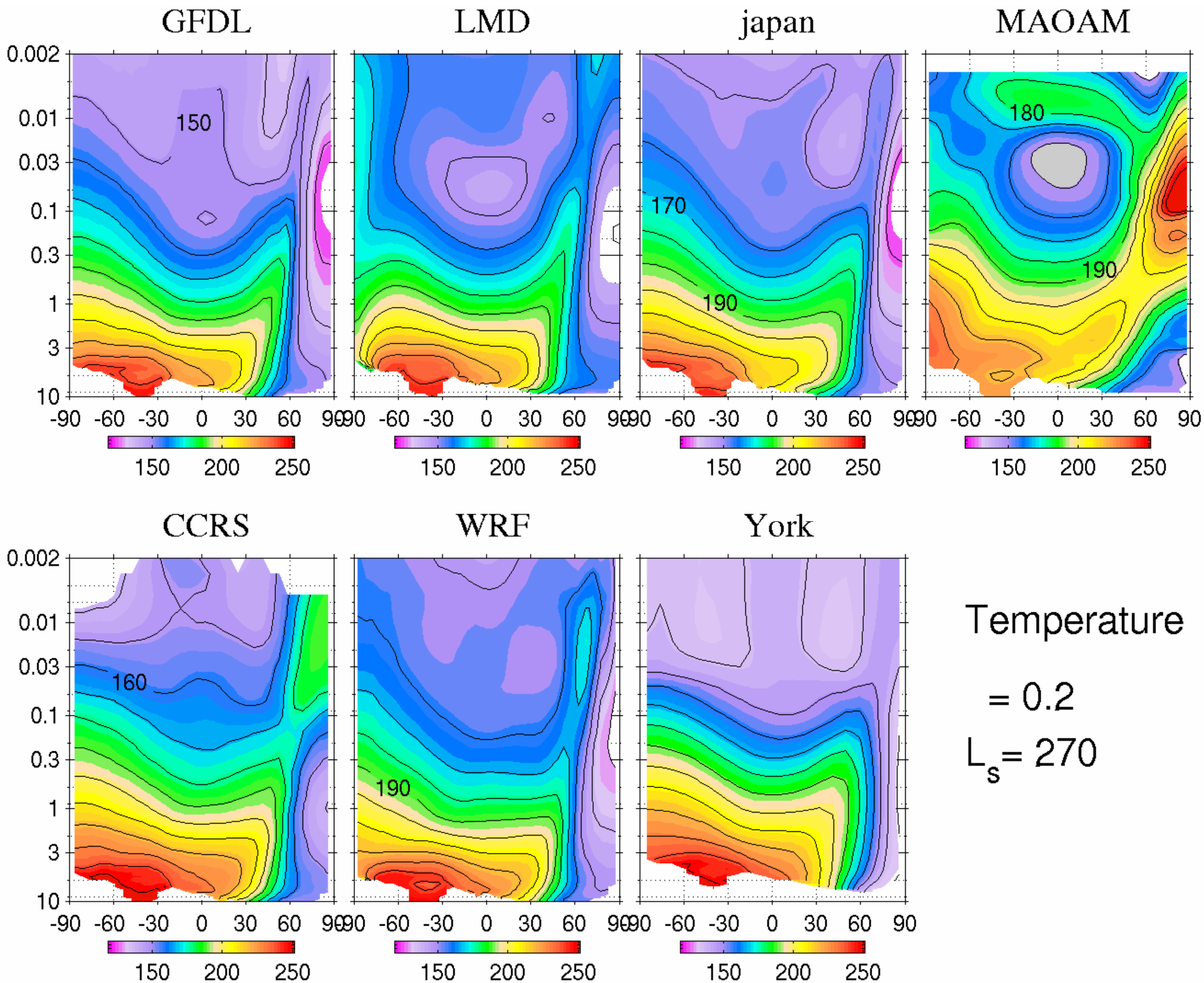

GFDL
LMD
japan
MAOAM
CCRS
WRF
York
0.002
0.01
0.03
0.1
0.3
1
3
10
-90 -60 -30 0 30 60 90
150 200 250
180
170
160
Temperature
= 0.2
L_s= 180

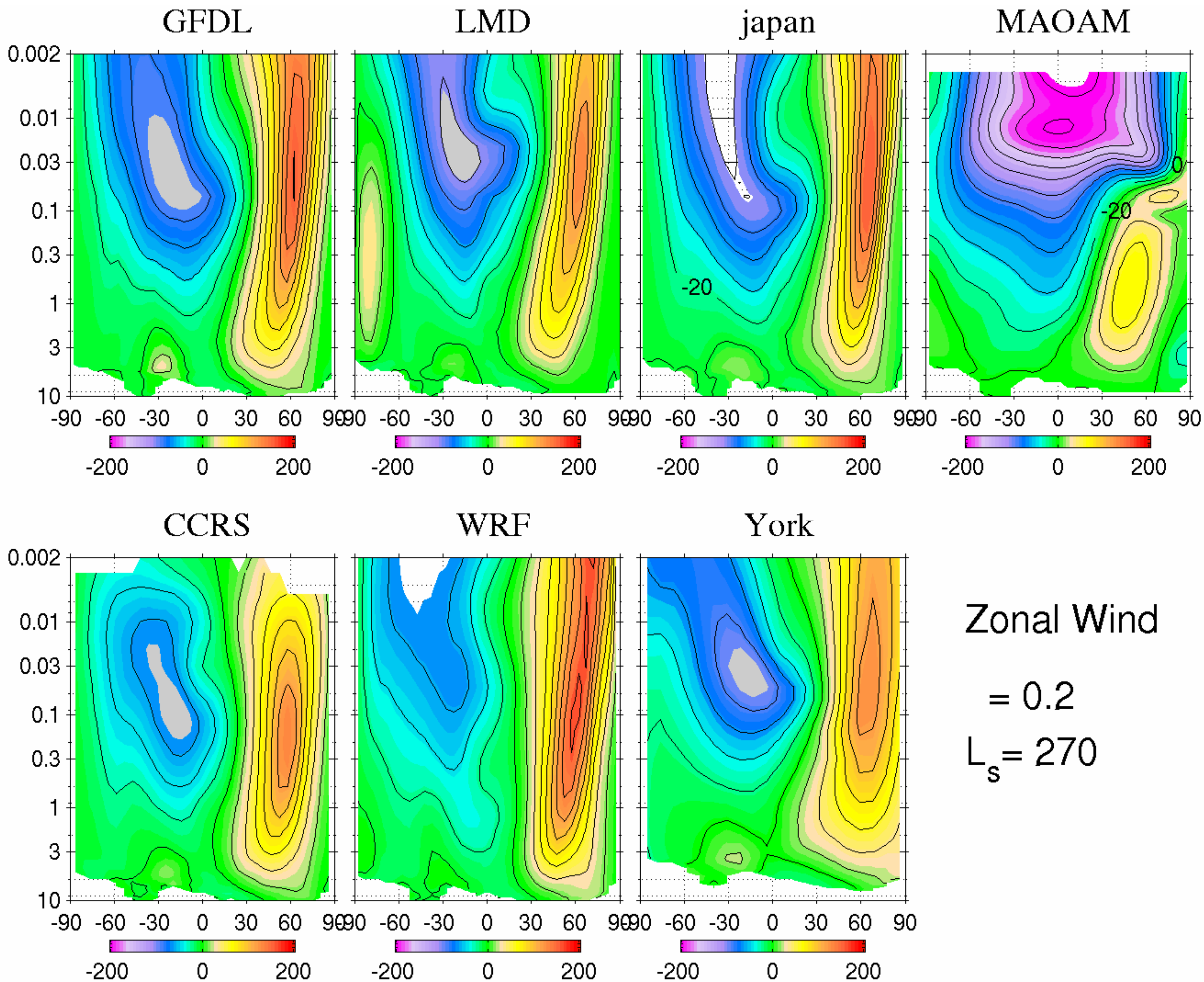

GFDL
LMD
Japan
MAOAM
CCRS
WRF
York
Zonal Wind
= 0.2
L_s= 180



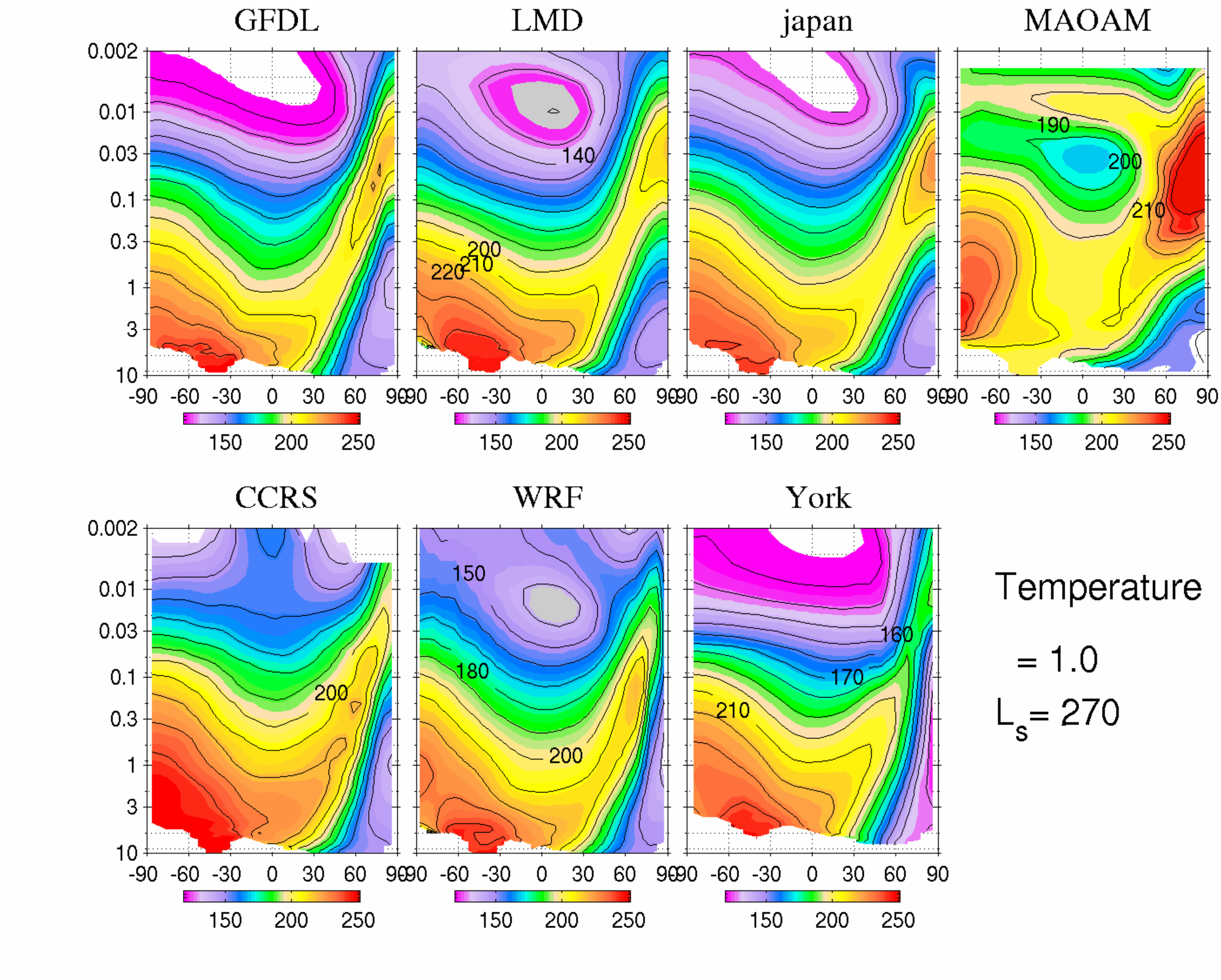
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
Temperature
= 0.2
L_s= 090


GFDL
LMD
japan
MAOAM
CCRS
WRF
York
0.002
0.01
0.03
0.1
0.3
1
3
10
-90 -60 -30 0 30 60 90
-200 0 200
-100
0
Zonal Wind
= 0.2
Ls= 090

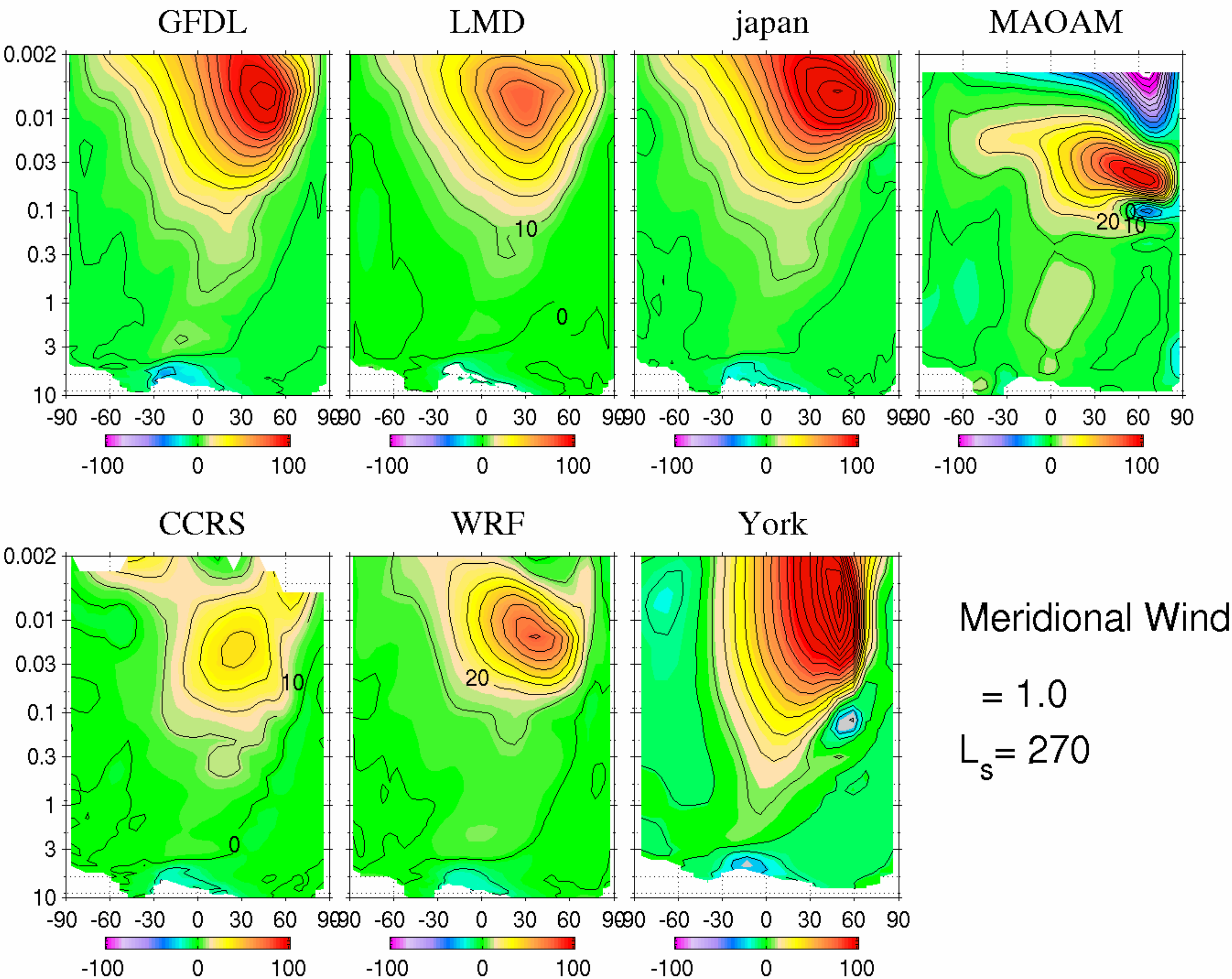

GFDL
LMD
japan
MAOAM
CCRS
WRF
York
0.002
0.01
0.03
0.1
0.3
1
3
10
-90 -60 -30 0 30 60 90
150 200 250
150
170
180
190
160
Temperature
= 0.2
L_s= 270



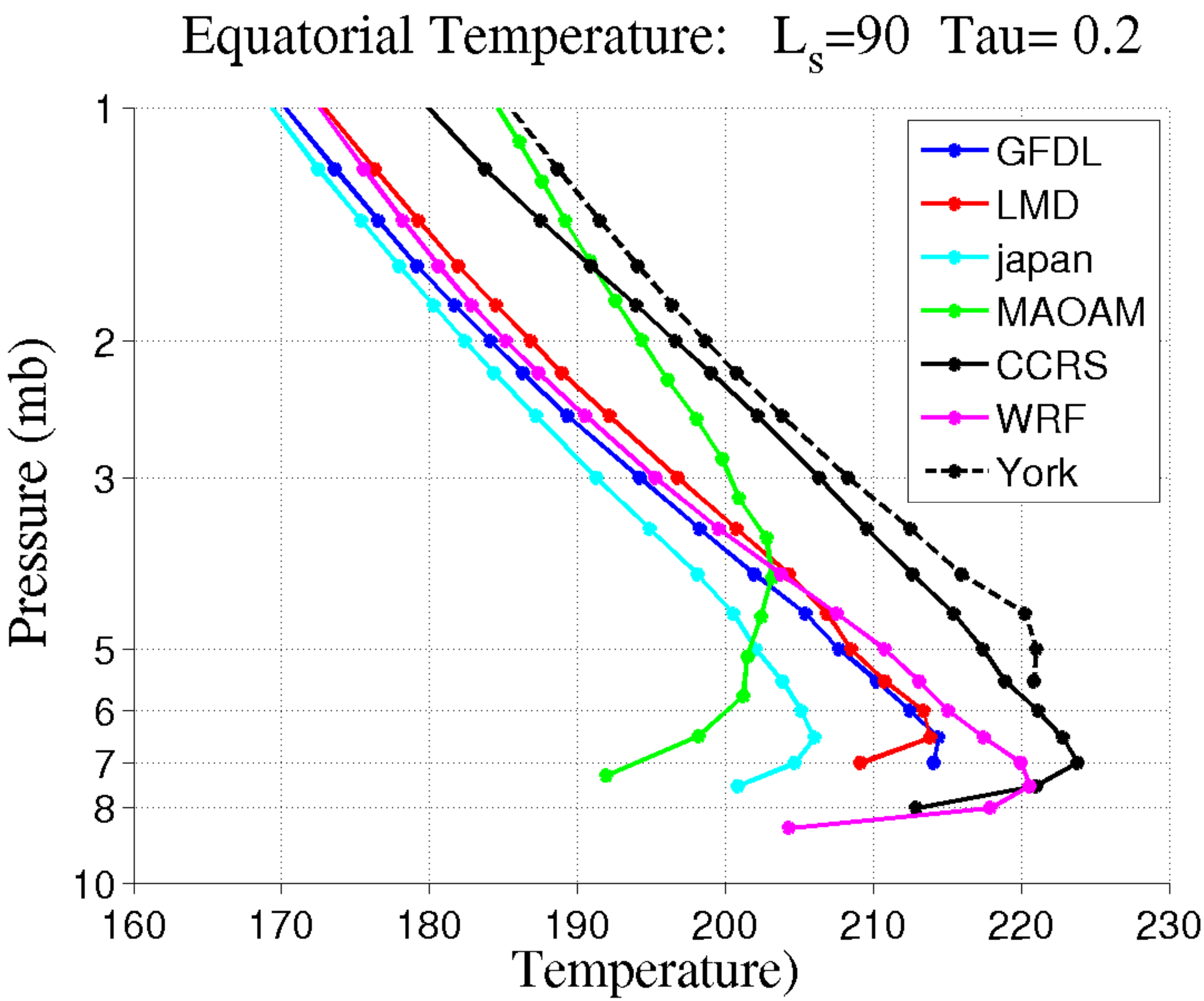
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
0.002
0.01
0.03
0.1
0.3
1
3
10
-90 -60 -30 0 30 60 90
-200 0 200
-20
0
Zonal Wind
= 0.2
L_s= 270



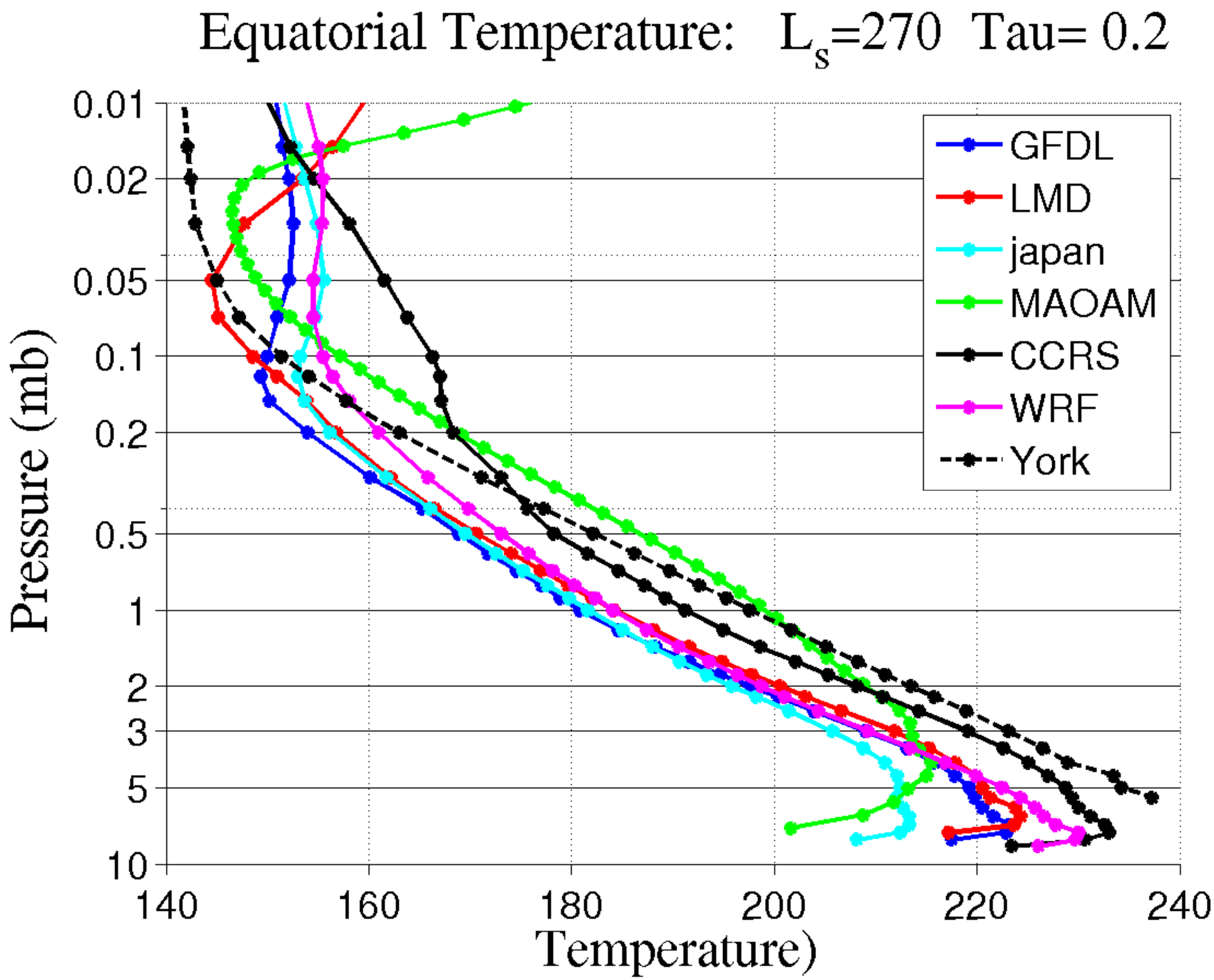
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
0.002
0.01
0.03
0.1
0.3
1
3
10
-90 -60 -30 0 30 60 90
150 200 250
140
200
210
220
190
200
210
200
150
180
200
160
170
210
Temperature
= 1.0
L_s= 270

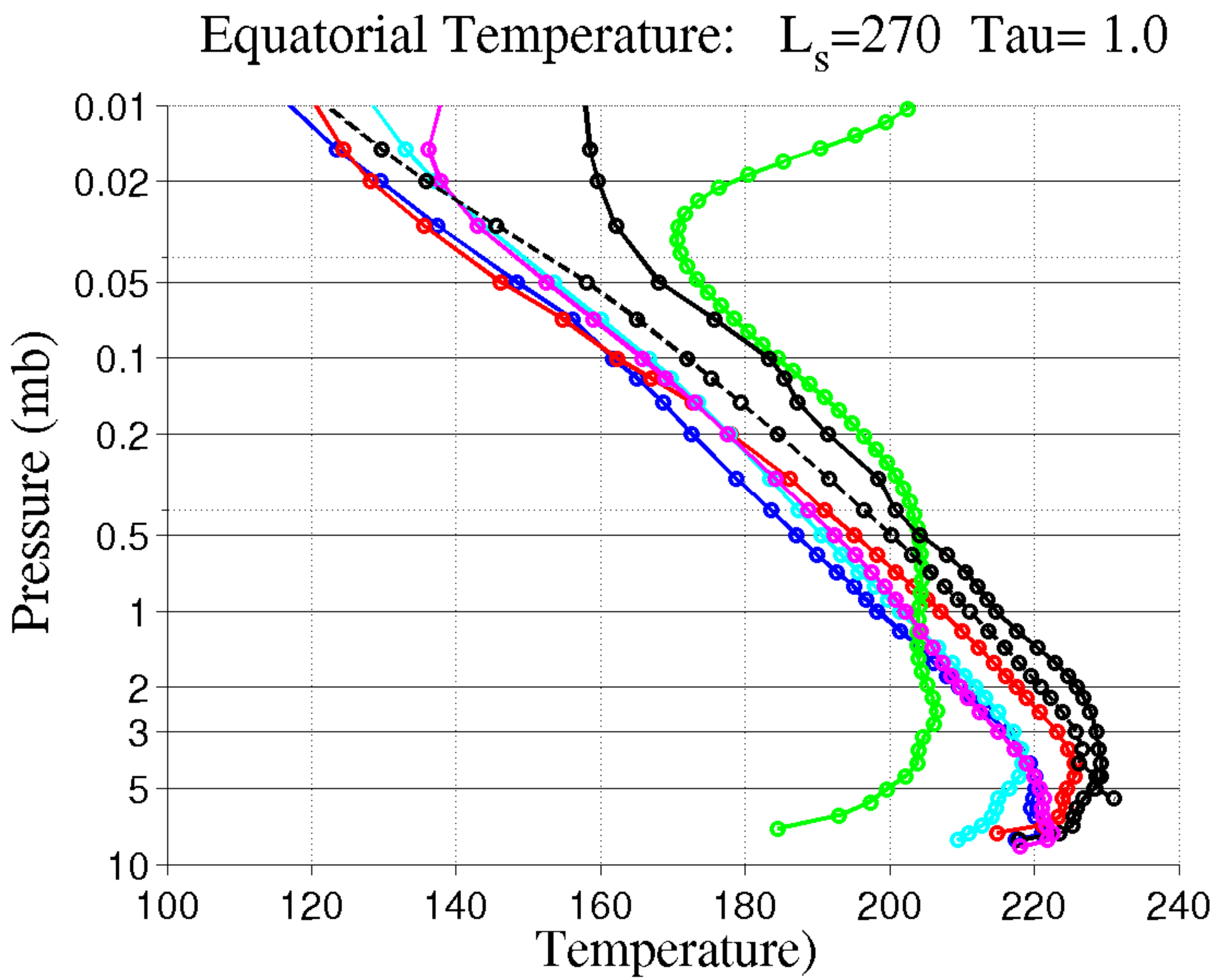


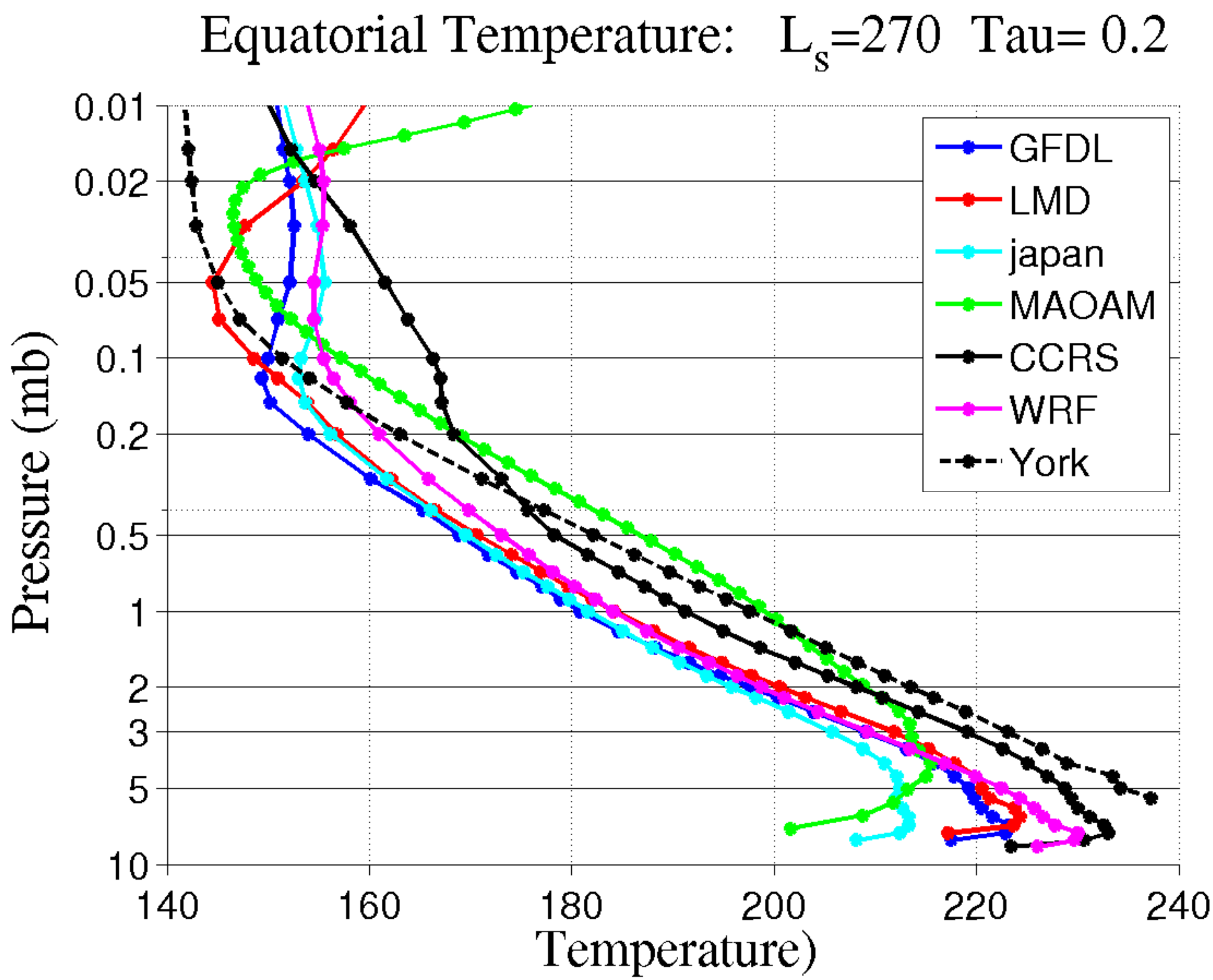
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
0.002
0.01
0.03
0.1
0.3
1
3
10
-90 -60 -30 0 30 60 90
-100 0 100
10
0
20
Meridional Wind
= 1.0
L_s= 270



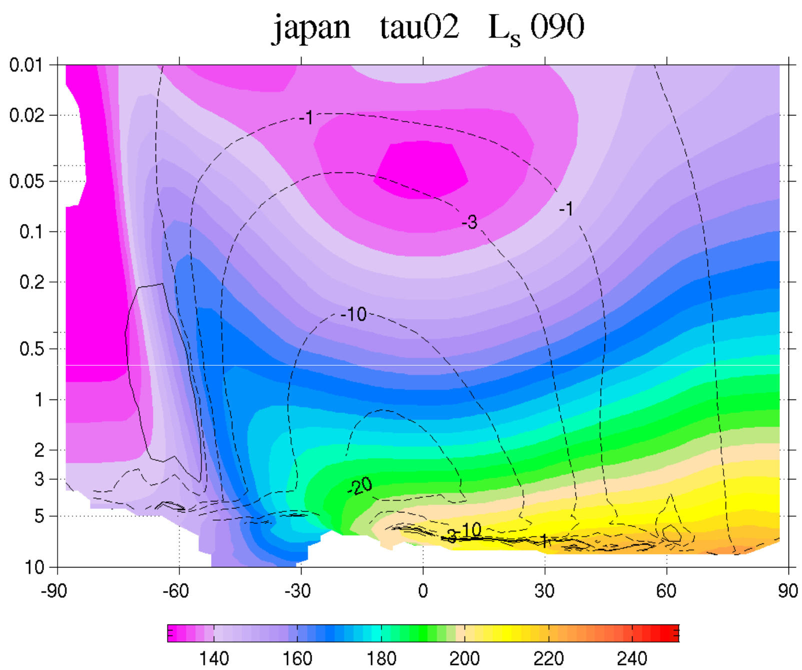
Equatorial Temperature: L_s=90 Tau= 0.2
Pressure (mb)
Temperature)
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
1
2
3
5
6
7
8
10
160
170
180
190
200
210
220
230


Equatorial Temperature: L_s=270 Tau= 0.2
Pressure (mb)
0.01
0.02
0.05
0.1
0.2
0.5
1
2
3
5
10
140
160
180
200
220
240
Temperature)
GFDL
LMD
japan
MAOAM
CCRS
WRF
York


Equatorial Temperature: L$_s$=270 Tau= 1.0
Pressure (mb)
0.01
0.02
0.05
0.1
0.2
0.5
1
2
3
5
10
100
120
140
160
180
200
220
240
Temperature)



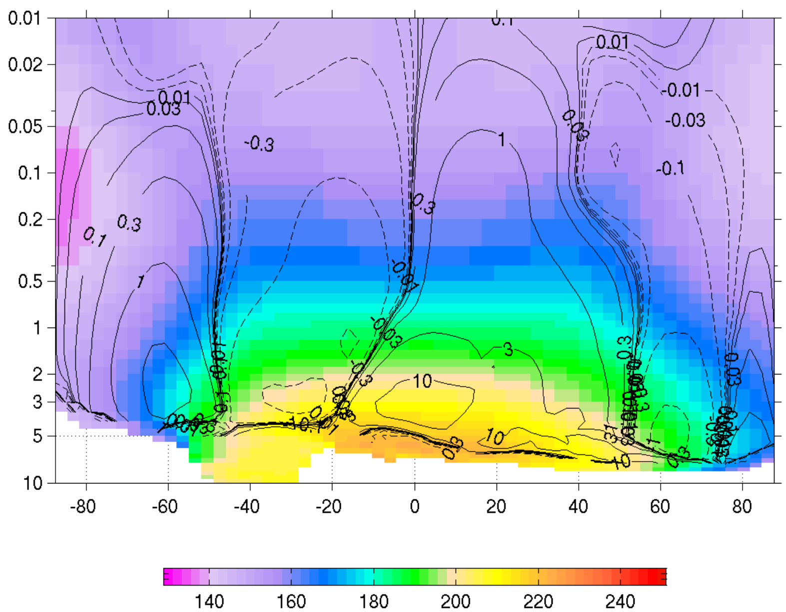
Equatorial Temperature: Ls=270 Tau= 0.2
Pressure (mb)
0.01
0.02
0.05
0.1
0.2
0.5
1
2
3
5
10
140
160
180
200
220
240
Temperature)
GFDL
LMD
japan
MAOAM
CCRS
WRF
York



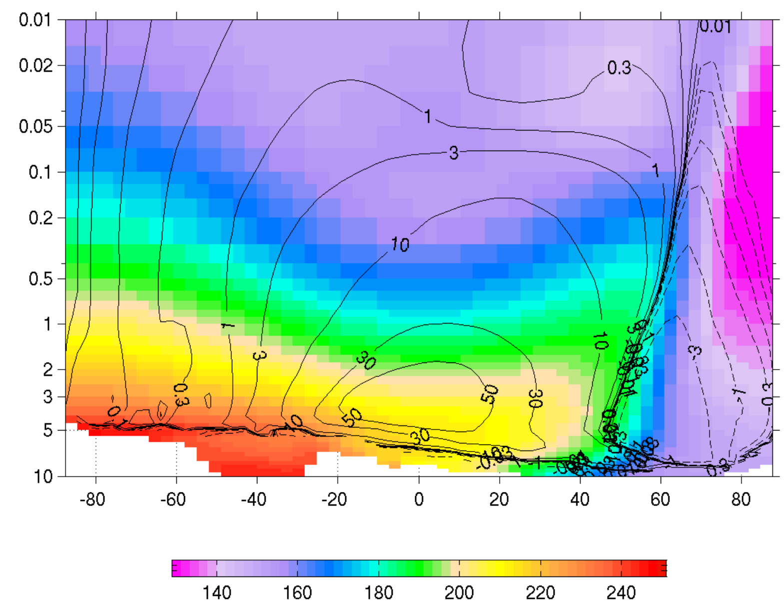
Temperature and Streamfunction

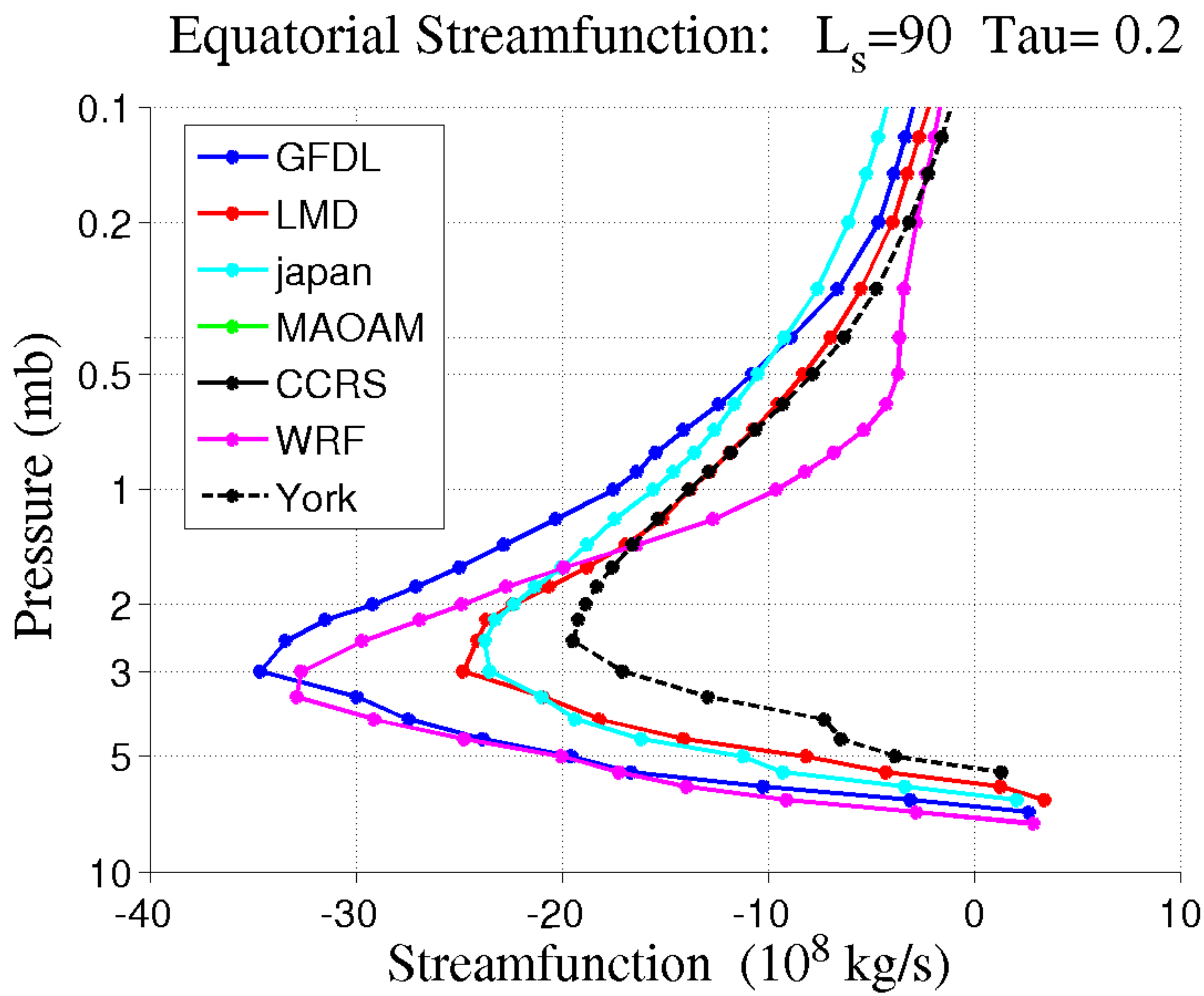
Streamfuncton: 10^8 kg/s

Ls= 180



Ls= 270



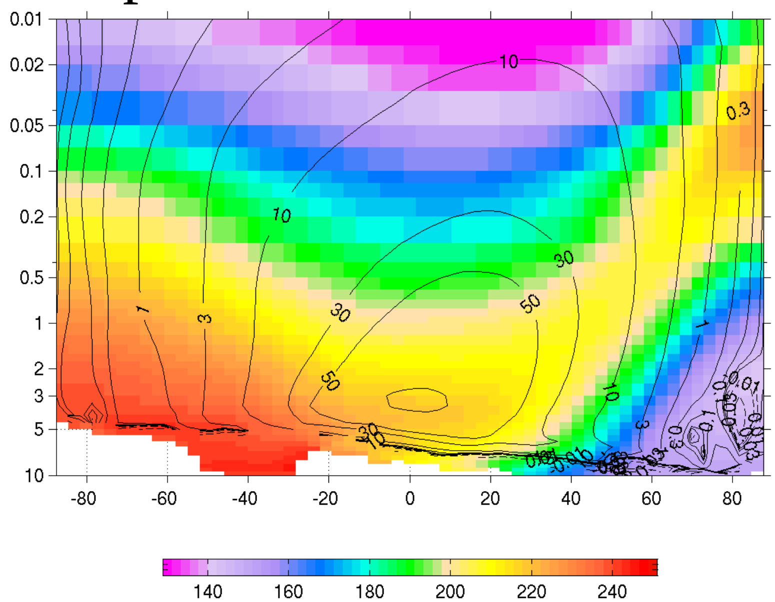


Equatorial Streamfunction: L_s=90 Tau= 0.2
Pressure (mb)
0.1
0.2
0.5
1
2
3
5
10
-40
-30
-20
-10
0
10
Streamfunction (10^8 kg/s)
GFDL
LMD
japan
MAOAM
CCRS
WRF
York

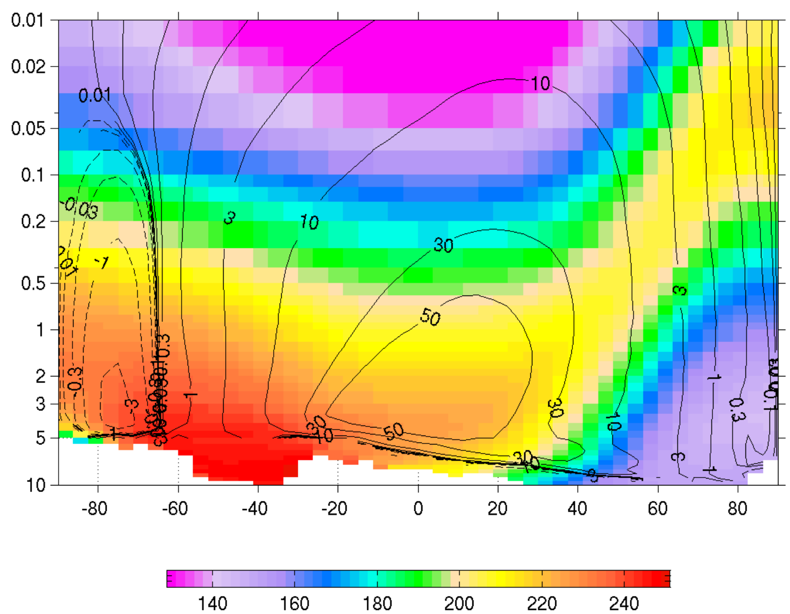
Temperature and Streamfunction

L_s= 270; τ= 1.0

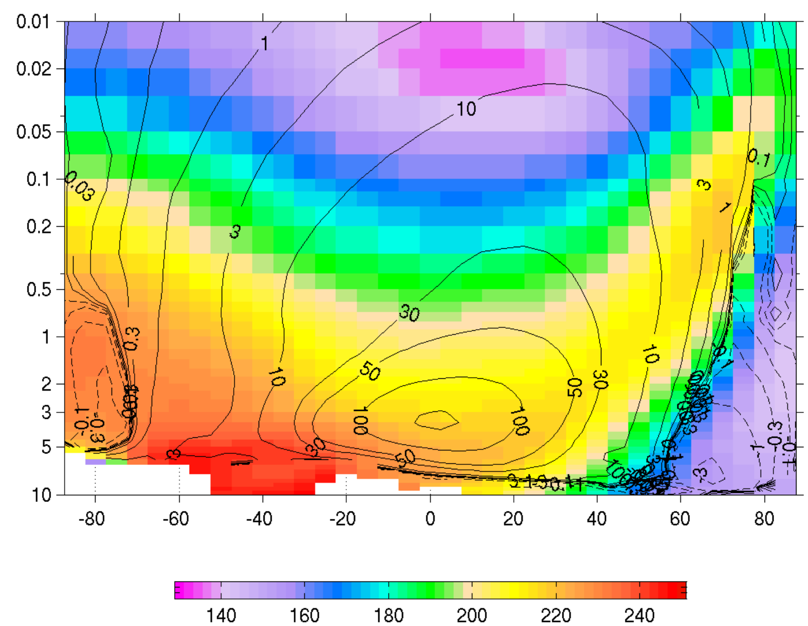
Japan

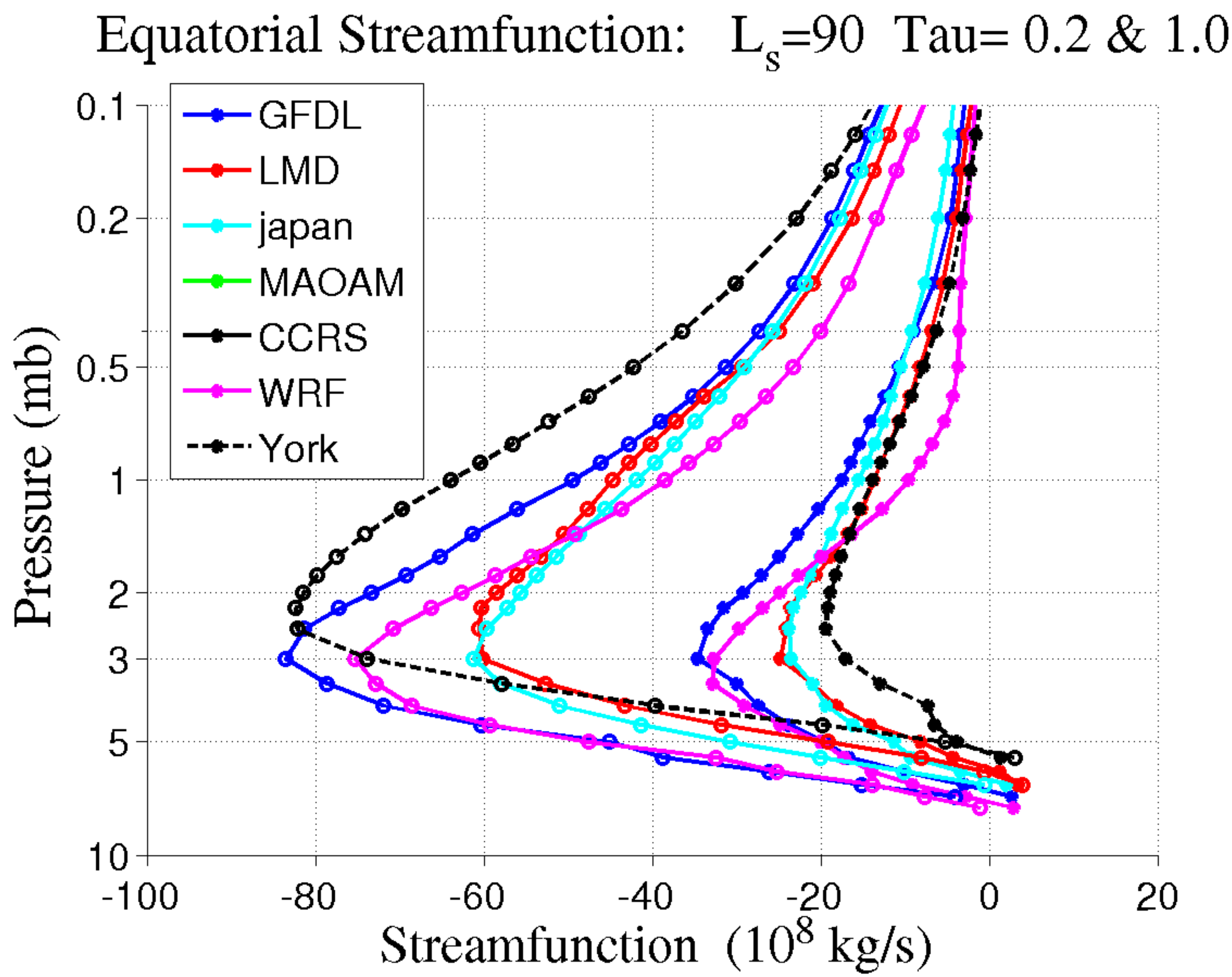


LMD

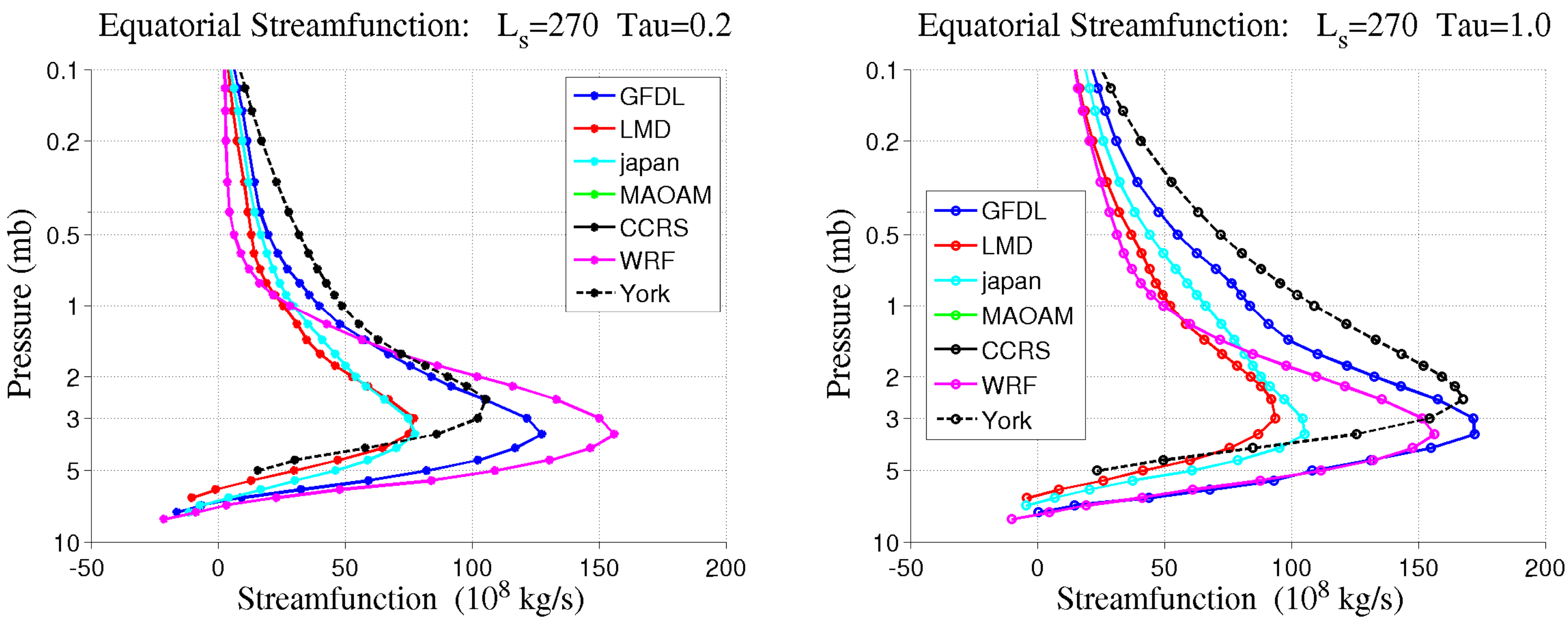


WRF





Equatorial Streamfunction: L_s=90 Tau= 0.2 & 1.0
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
Pressure (mb)
0.1
0.2
0.5
1
2
3
5
10
-100
-80
-60
-40
-20
0
20
Streamfunction (10^8 kg/s)



Equatorial Streamfunction: L_s=270 Tau=0.2
Pressure (mb)
Streamfunction (10^8 kg/s)
GFDL
LMD
japan
MAOAM
CCRS
WRF
York
Equatorial Streamfunction: L_s=270 Tau=1.0
Pressure (mb)
Streamfunction (10^8 kg/s)
GFDL
LMD
japan
MAOAM
CCRS
WRF
York

Thermal Tides

Solar forcing;   heat transport from the surface

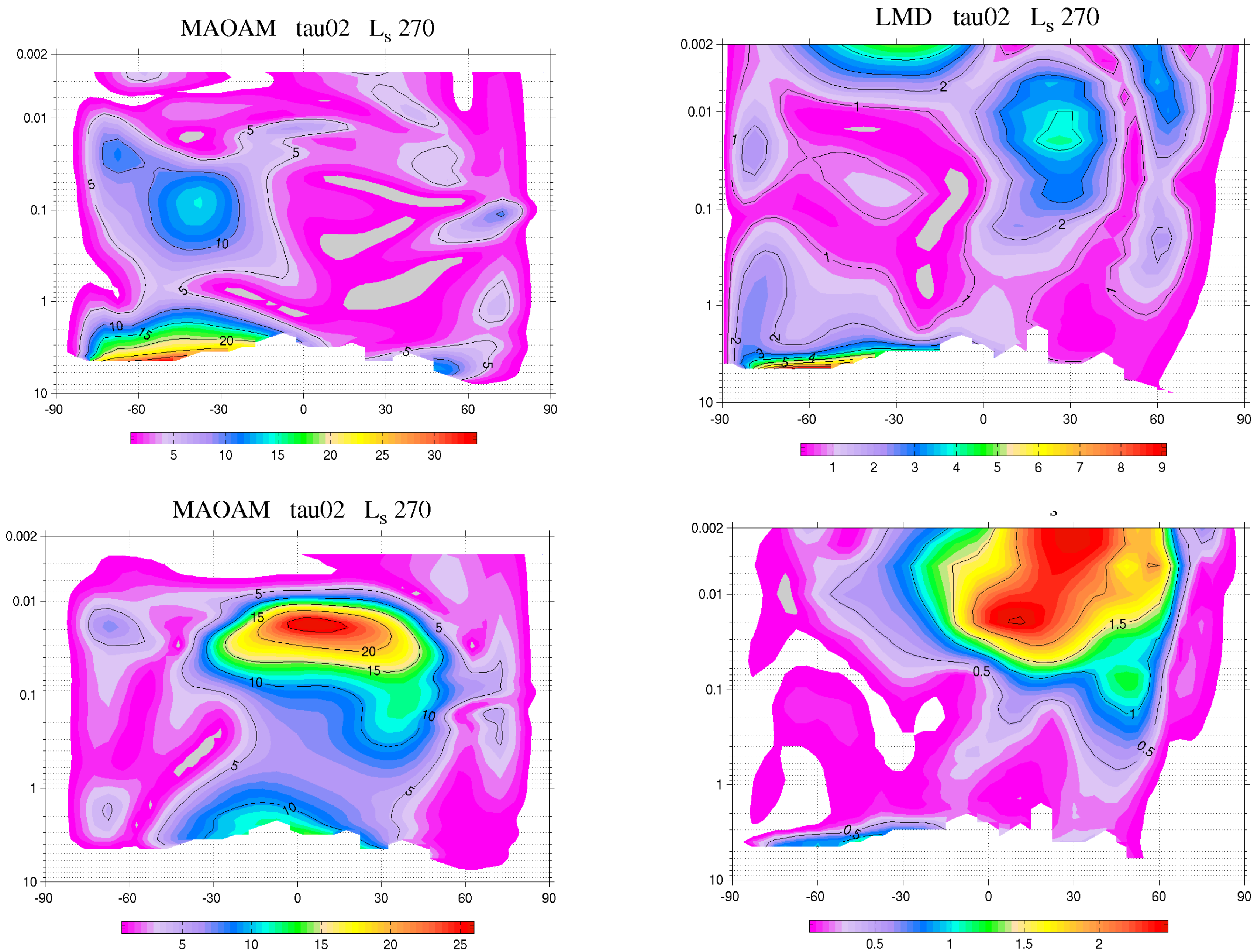
absorption of solar radiation by aerosols

Propagation: Influence of zonal mean circulation

Dissipative process: provides a means of wave influence on the zonal mean circulation

First-order agreement between all models except MAOAM:

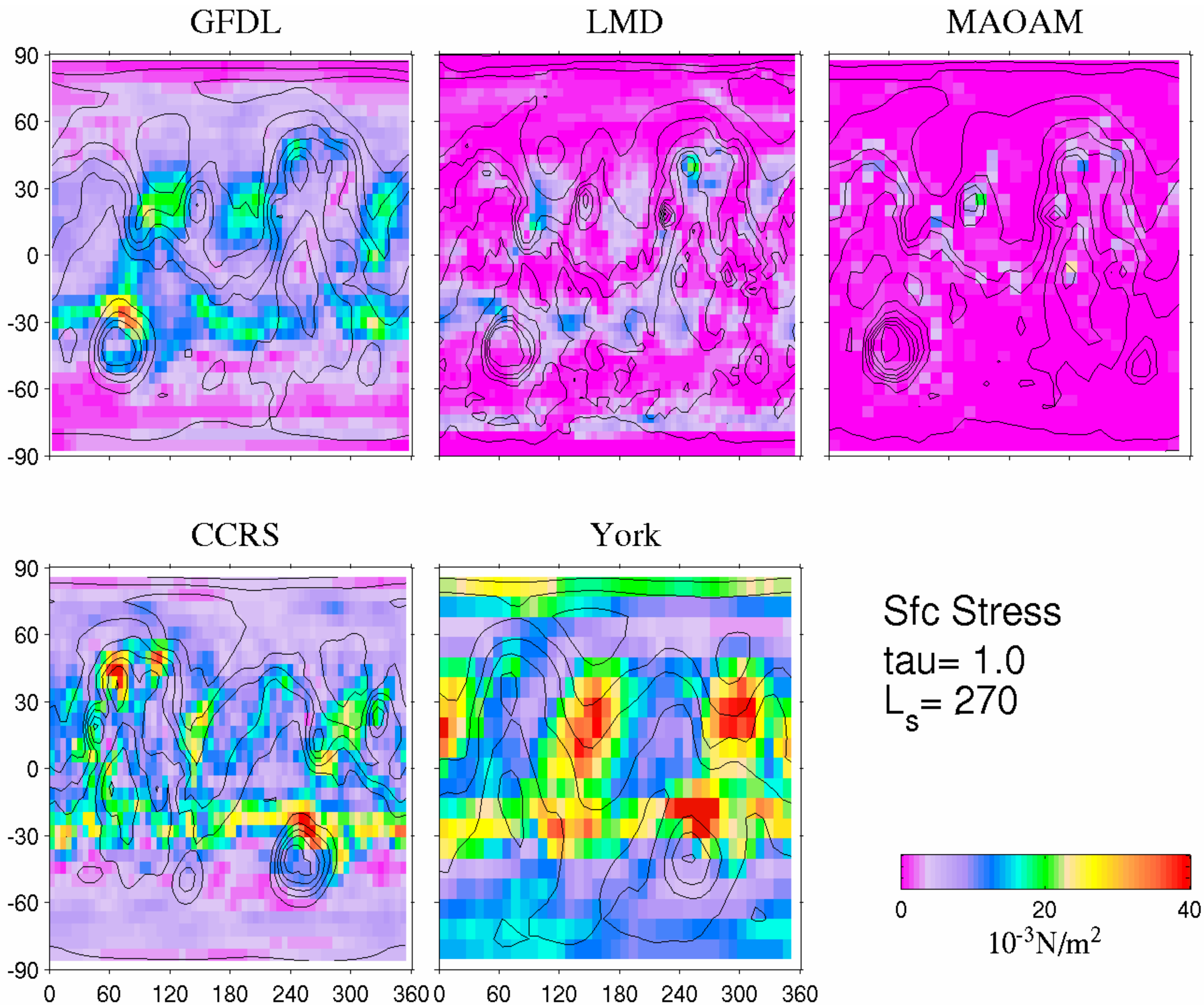
Large amplitude tide forcing and dissipation in the MAOAM model is evidently responsible for strong polar temperatures

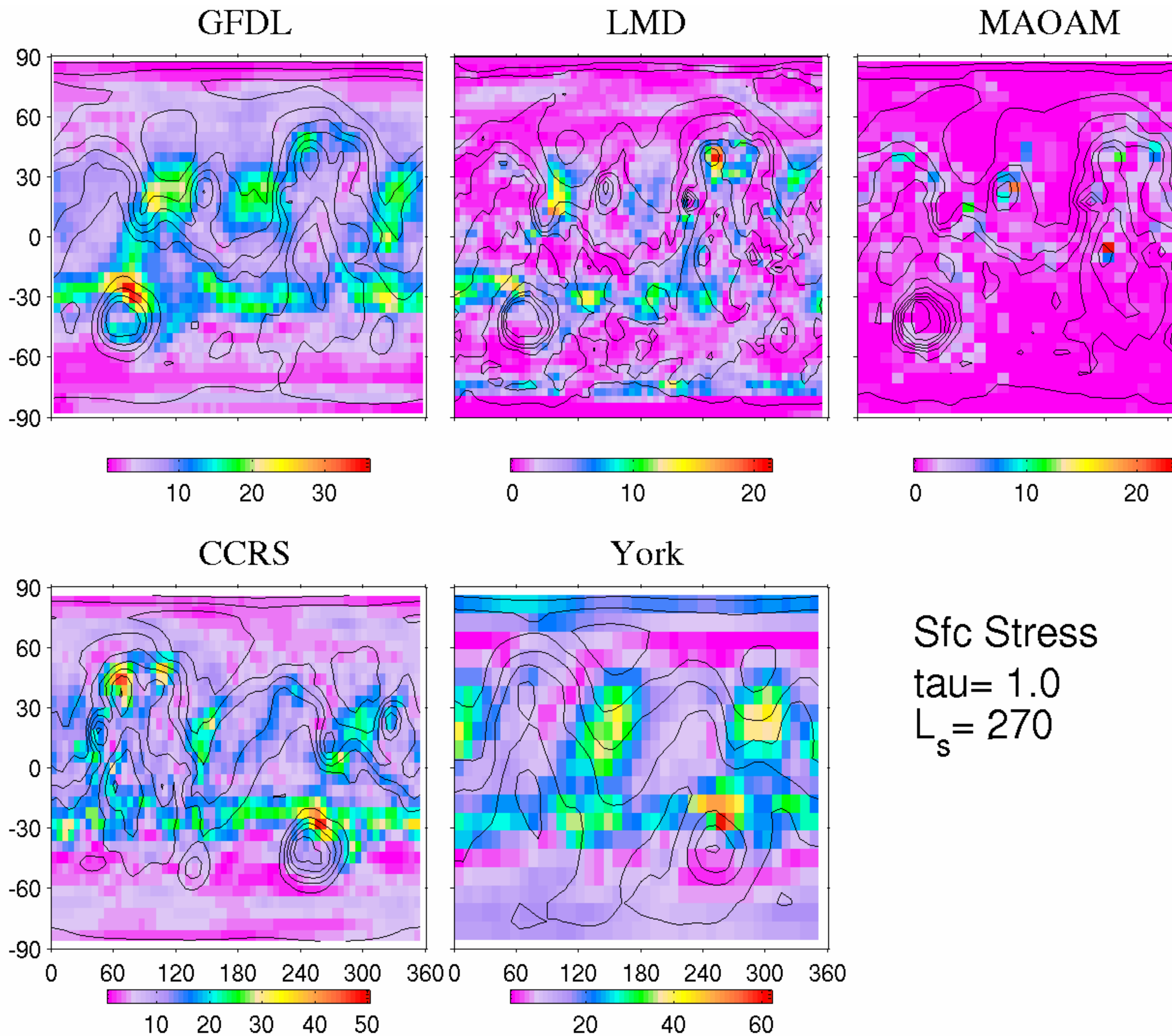

MAOAM tau02 L_s 270
LMD tau02 L_s 270
MAOAM tau02 L_s 270
0.002
0.01
0.1
1
10
-90
-60
-30
0
30
60
90

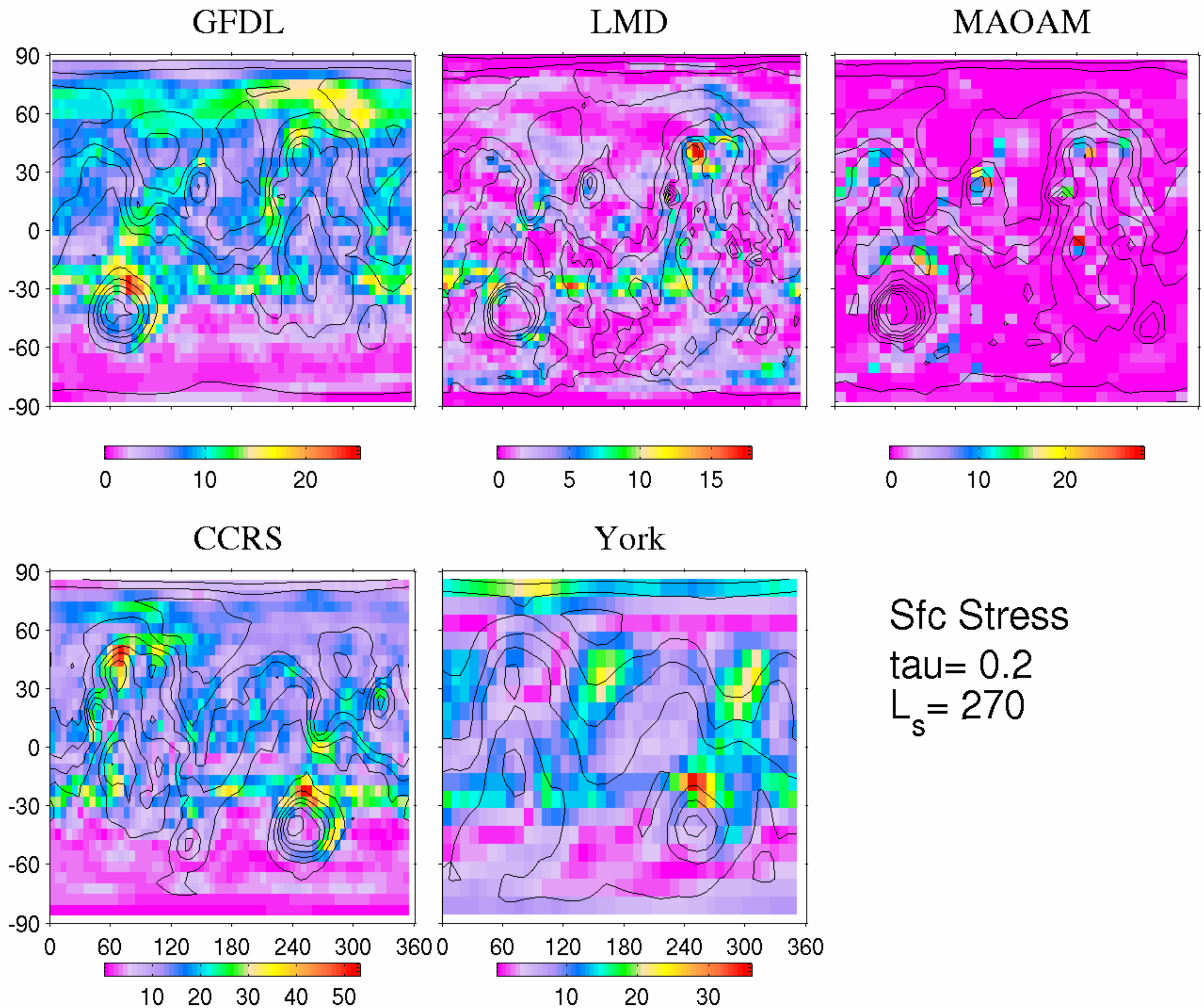
Surface Stress

Examined plots of the spatial distribution of the maximum surface stress in a diurnal composite time series

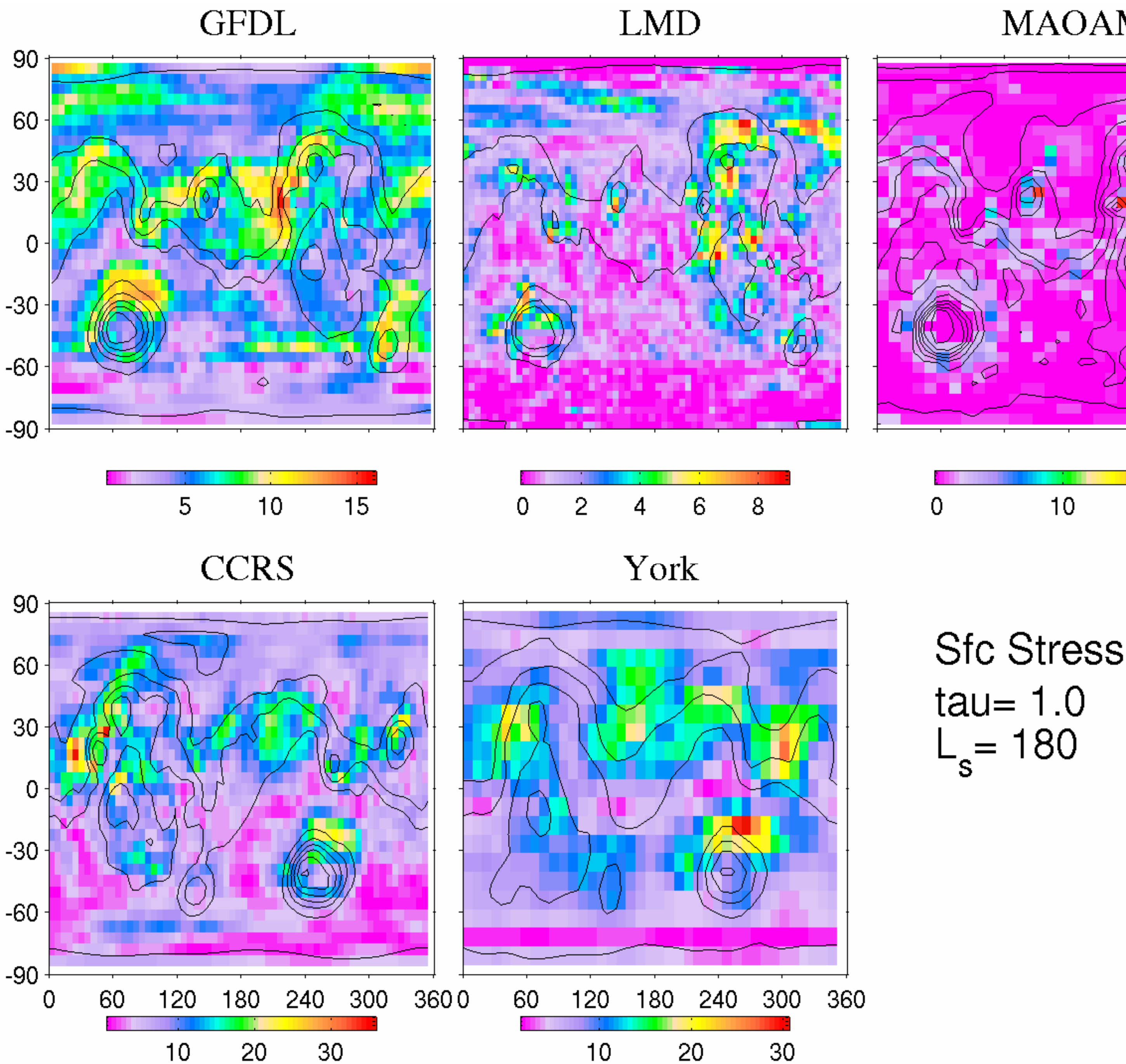
Surface stress will vary with model horizontal and vertical resolution and boundary layer parameterization

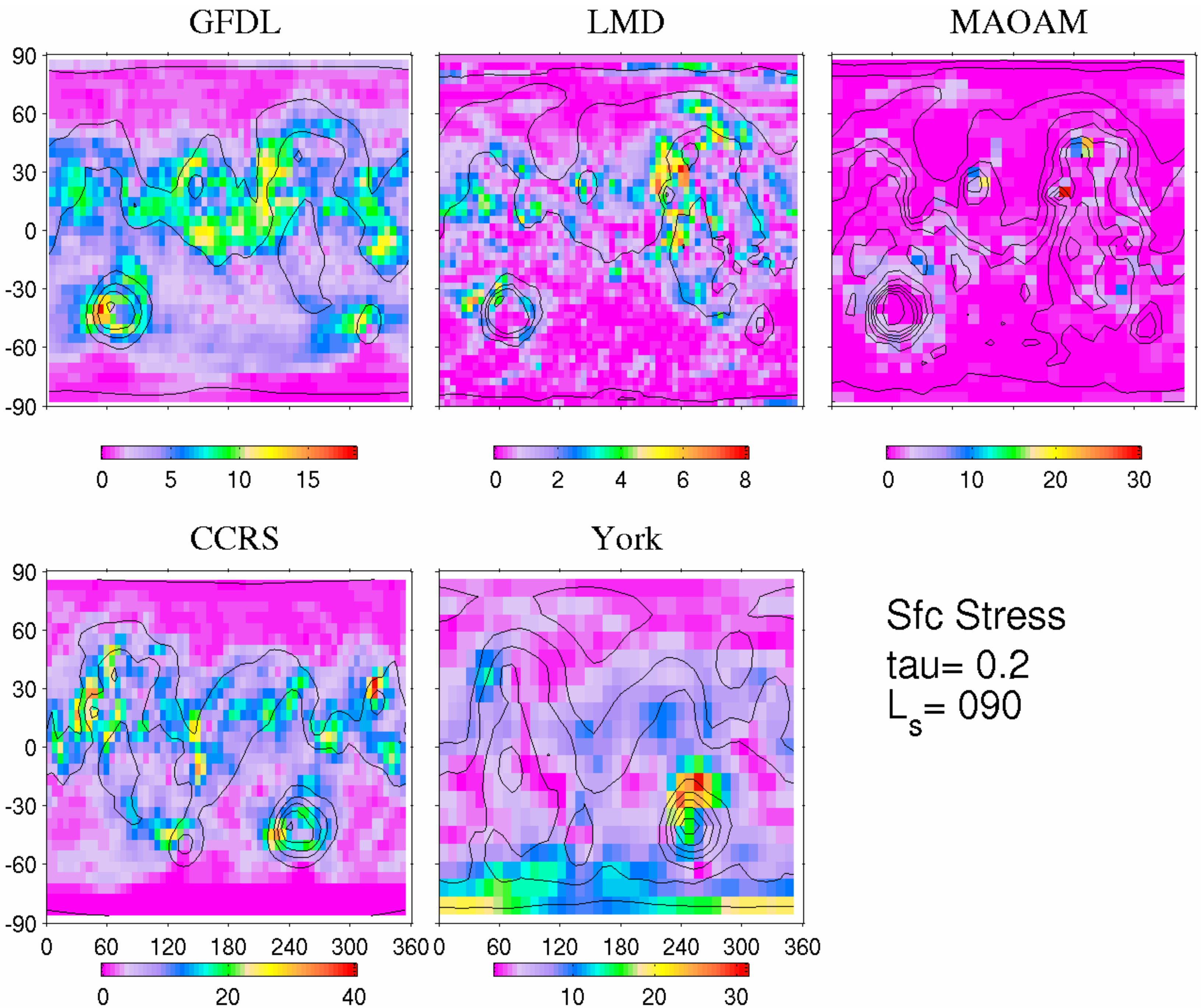

GFDL
LMD
MAOAM
CCRS
York
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360
Sfc Stress
tau= 1.0
L_s= 270
0
20
40
10^{-3}N/m^2

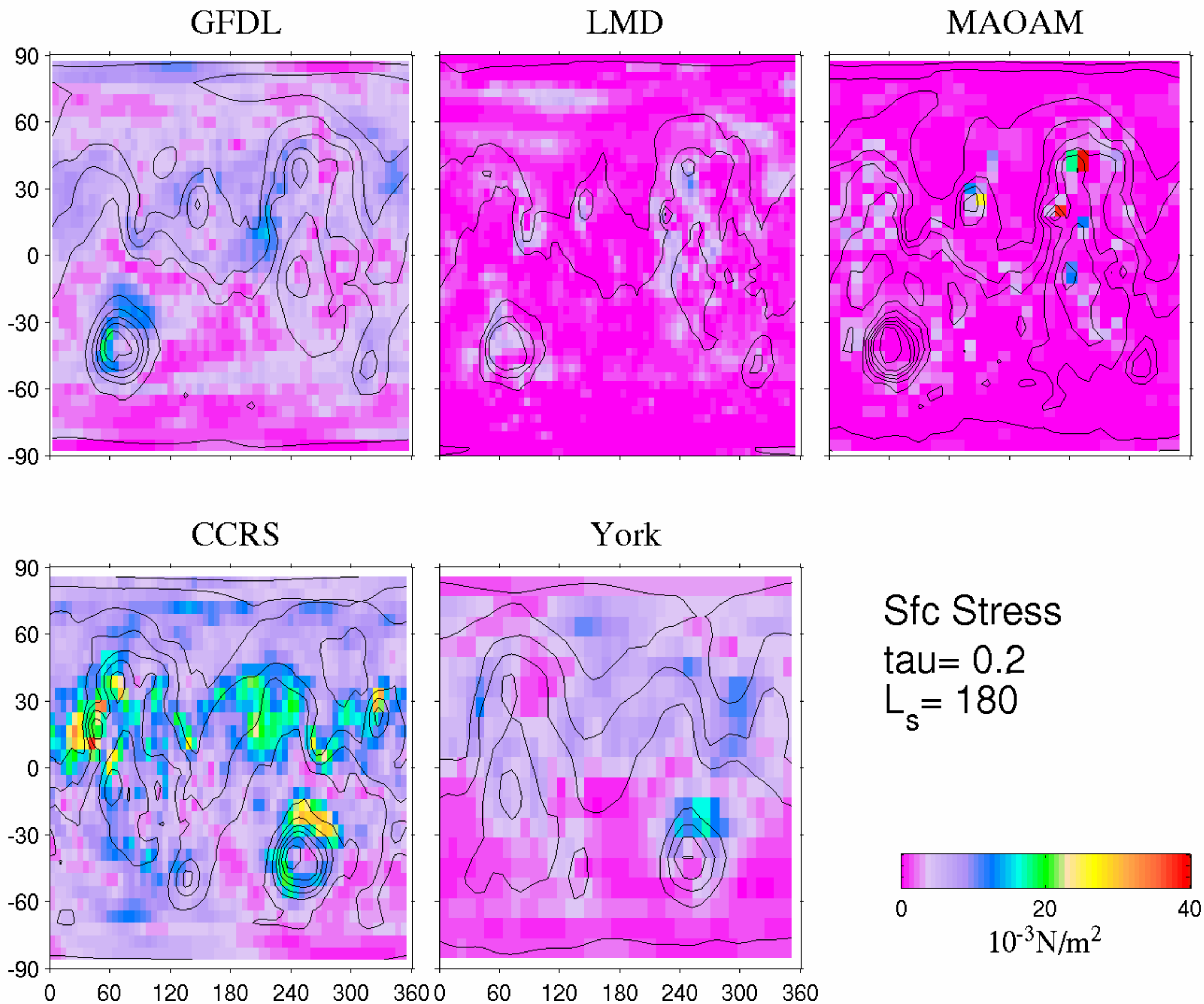

GFDL
LMD
MAOAM
CCRS
York
90
60
30
0
-30
-60
-90
10 20 30
0 10 20
0 10 20
0 60 120 180 240 300 360
10 20 30 40 50
20 40 60
Sfc Stress
tau= 1.0
L_s= 270



GFDL
LMD
MAOAM
CCRS
York
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360
0 10 20
0 5 10 15
0 10 20
10 20 30 40 50
10 20 30
Sfc Stress
tau= 0.2
L_s= 270


GFDL
LMD
MAOAM
CCRS
York
Sfc Stress
tau= 1.0
L_s= 180
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360
5
10
15
0
2
4
6
8
0
10
20
10
20
30
10
20
30


GFDL
LMD
MAOAM
CCRS
York
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360
0 5 10 15
0 2 4 6 8
0 10 20 30
0 20 40
10 20 30
Sfc Stress
tau= 0.2
L_s= 090



GFDL
LMD
MAOAM
CCRS
York
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360
Sfc Stress
tau= 0.2
L_s= 180
0
20
40
10^-3 N/m^2